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ORIGINAL ARTICLES.

I.—Preliminary note on the Sequence and Fossils of the Upper Triassic Strata of the Neighbourhood of St. Cassian, Tyrol.

By Miss Maria M. Ogilvie, B.Sc. (Lond.).

During the past autumn, at the kindly suggestion of Prof. Baron von Richthofen, I spent some months in the study of the strata and fossils of the neighbourhood of St. Cassian. My object was to endeavour, if possible, to determine the most natural subdivisions of these classic strata, and to fix their characteristic fossils. As the results I have obtained are somewhat novel, and may prove of interest to those who are familiar with the enigmatical character of the stratigraphy of the beautiful region of the Dolomites, I may, perhaps, be permitted to give in this place a short summary of my conclusions, in anticipation of a detailed paper upon the subject.

In 1860, von Richthofen[1] published the first detailed examination of the Triassic strata in South Tyrol; and in this work he sought to explain the geological features of the Upper Trias by application of Darwin's theory of the conditions attending the growth of Coral-reefs. In the well-known work of Mojsisovics ("Die Dolomit-Riffe von Süd-Tirol und Venetien," Wien, 1879) the Upper Triassic strata of the region are grouped in five main divisions in ascending order.

Upper Trias.	*Noric* Strata = 1. *Buchenstein* Beds. 2. *Wengen* Beds.	
	Karnic Strata = 3. *Cassian* Beds. 4. *Raibl* Beds. 5*a*. *Dachstein Kalk* (in part).	
	Rhætic strata = 5*b*. *Dachstein Kalk* (in part).	

This succession of Upper Trias is but slightly modified from Richthofen's; one main point of difference is that Richthofen places between the Cassian and Raibl Beds the *Schlern Dolomite*, which he holds (1) to be younger than the Buchenstein, Wengen, and part of Cassian strata, and (2) in some cases to rest unconformably, as at Schlern mountain, on Mendola Dolomite (Muschelkalk); (3) to be of local occurrence. Mojsisovics, on the other hand, states that the three groups of the Buchenstein, Wengen, and Cassian Beds are *normally* stratified, but that *all three are locally* represented by massive non-stratified dolomitic reefs of the same age. He draws attention also to the appearance of thinner lenticular beds of dolomite at any horizon in the Wengen and Cassian strata.

[1] Geognostiche Beschreibung der Umgegend von Predazzo, Sanct Cassien und der Seisser Alpe in Süd-Tyrol. 4to. Gotha.

Both Richthofen and Mojsisovics are of opinion that the Cassian and Raibl beds with their characteristic faunas are essentially of limited occurrence, having been deposited in occasional lagoons and quiet bays.

My personal mapping of the stratified deposits near St. Cassian and at Seeland Thal and Cortina has enabled me to show that a further subdivision of the Wengen and Cassian strata is possible and necessary; and the detailed study of the rocks and fossils makes it clear that each of these proposed subdivisions is distinguished by both lithological and palæontological characters peculiar to itself. The most natural grouping of the strata seems to me to be as follows in descending order:—

DACHSTEIN KALK .....A greyish-white dolomite, rarely limestone; the rock is stratified, and usually of compact character. *Megalodon triquetus* (Wulf.).

RAIBL BEDS. .....Dolomitic breccias, bituminous limestones, sandstones, beds of gypsum, pure dolomite, and variegated ferruginous clays.
Fossils: *Ostrea montes-caprilis* (Klipstein), *Myophoria Kefersteinii* (Goldf.), *Corbis Mellingi* (Hauer), etc.

'Cassianer Strata,' and contemporaneous 'Cassianer dolomite,' (Mojsisovics).

SCHLERN DOLOMITE .....A dolomite of drusy, highly crystalline character; fossils rare; corals, encrinites, bivalves.

CASSIAN BEDS.

Upper Cassian or Prelongei zone. — Fossiliferous marls, dark clays, light grey shales and interstratified limestones. *Montlivaltia crenata* (Münst.), *Cladophyllia subdichotoma* (Sube.), *Anoplophora Münsteri* (Wissm.), *Avicula Gea*, d'Orb.

Middle Cassian or Muren zone. — Marls, impure clays and shales with interstratified oolitic sandstones and limestones, and beds of arragonite, the whole series showing admixture of volcanic mud.
Fossils few: *Mytilus Münsteri* (Klipst.), Encrinites, also plant-remains.

Lower Cassian or Stuores zone. — Dark fossiliferous marls and clays and interstratified beds of hard fossiliferous limestone. *Isastræa Gümbeli* (Laube.), *Nucula lineata* (Goldf.), *Cassianella decussata* (Münster), *Koninckia Leonhardi* (Wissm.), *Terebratula indistincta* (Beyrich).

'Wengener strata' and the contemporaneous horizon of 'Wengener Dolomite' (Mojsisovics).

WENGEN BEDS.

Up. Wengen.—Breccias (composed of limestone and volcanic material), thin-banded limestones and clays, thick beds of brownish sandstone—arragonite beds.
Posidonomya Wengensis (Wissmann), *Trachyceras furcatum* (Münster).

Lr. Wengen.
b. Tufaceous sandstones & impure limestones; black eruptive tuffs with or without augite porphyry. *Daonella Lommeli* (Wissm. sp.), and plant-remains (*Equisetites*, etc.)
a. Halobia shales, *Daonella Lommeli* (Wissm. sp.) (of local occurrence).

Horizon of the 'Buchensteiner beds and B. dolomite' (Mojs.). — Augite porphyry or volcanic series, and Buchenstein strata.

Below come the equivalents of the Muschelkalk, which lay outside the sphere of my researches.

There is no great difficulty is establishing this detailed sequence, as the beds between the Buchenstein strata and the Dachstein are exposed in good sections; each zone is individualized by its own lithological features and the characteristic fossils were collected on the ground. There is a replacement of older by newer forms in passing upwards; but no recurrence. The two great calcareous dolomitic series—the Schlern-Dachstein above and the Muschelkalk below—are separated over a large district by the entire non-dolomitic series, and even the well-known Cipit limestones prove themselves to be constant Corallinè zones in the Cassian period.

In determining the limit of Wengen and Cassian strata, I wished to emphasize the first appearance in Triassic time of the varied and highly characteristic fauna of St. Cassian. In this respect my mapping differs in many places from that of Mojsisovics, *e.g.* in the typical St. Cassian district the Cassian strata are limited in the map of Mojsisovics to the Prelongei heights, and correspond generally to the "Upper Cassianer Strata" in the succession given above. At the same time Mojsisovics mentions in his text that the Cassian fossils are found on both the Stuores and Buchenstein slopes of the Prelongei ridge. These slopes, from which the main part of the Cassian fossils are derived, I have mapped as Middle and Lower Cassian strata. Again, on the Seisser Alpe, Mojsisovics maps no Cassian strata, preferring to regard the fossils in Cipit Alpe, etc., as being of Wengen age, although remarking that they resemble the later Cassian fossils. In other places, his so-called "Riff-Kalk," or "Cipit-Kalk," is said to thin out in Wengen strata or in Cassian strata. The "Riff-Kalk" contains Cassian fossils, and is of Cassian age.

By means of the above subdivisions, and certain zones in these, I have also found it possible to show that the district is cut up by many dislocations which could not previously have been traced through the Wengen and Cassian strata; but this part of my work is not yet finished. Another fact which appears is that the Raibl strata lie always above the Schlern Dolomite, and that they are different in character, and stratigraphically separated from, the Cassian strata, which invariably lie below the Schlern Dolomite. This has a distinct bearing on the much-discussed question of the "*Cardita strata*" in the North Alps. In the carefully-worked sections of N. or Bavarian Alps the "*Upper Cardita*" Beds are proved to be Raibler strata resting upon "Wetterstein Kalk," while the *Partnach strata*, which afford Cassian, Wengen and Buchenstein fossils, underlie the Wetterstein Kalk.

II.—On the Occurrence of a New Form of *Discinocaris* in the Graptolitic Beds of the "Colonie Haidinger" in Bohemia.

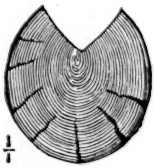
By Professor Ottamar Novák.

In the Quart. Journ. Geol. Soc., vol. xxxvi. 1880, p. 617, Mr. John E. Marr mentions having examined three specimens of a Phyllopodiform Crustacean discovered by Mr. Martin Dusl in the strata of "Colonie Haidinger," situated not far from the village of Gross-chuchle, south of Prague.

The specimens were then identified with *Discinocaris Browniana*, H. Woodw., figured and described in the same Journal, vol. xxii. 1866, p. 503, pl. 25, figs. 4, 5, and 7. They are also mentioned by Dr. H. Woodward and Prof. T. Rupert Jones in the Third Report of the Committee on the Fossil Phyllopoda of the Palæozoic Rocks, 1885, p. 2, under Mr. Marr's specific determination.

Having worked for some time past on a revision of the fossil Phyllopoda occurring in the Palæozoic rocks of Bohemia, I examined the three specimens in Mr. Dusl's collection, besides two others collected by myself in the same beds some years ago.

The following figure and description give sufficient evidence of the characters of the fossil in question.



Discinocaris Dusliana, Novák. Nat. size.
In the Geological Museum of the Bohemian University at Prague.

Description.—The shield flattened, oval in outline, without any median suture, but truncated in front by a nuchal notch, leaving a broad re-entrant angle, with rather concave sides and with an apex reaching about one-third of the shield's original length. Width of the nuchal notch precisely one-sixth of the entire circumference. Surface finely striated; the striæ disposed excentrically round about the apex of the frontal notch. The triangular frontal piece wanting in all five specimens under examination. The shield, if complete, would be about 22 mm. long, 19 mm. broad. The total length from the apex of the notch to the posterior margin being 15 mm.; slope of nuchal suture about 45°.

The superficies of the shield seems to have been originally somewhat convex, but appears to have been flattened by forcible compression, as indicated by the radiate fissures in our Woodcut.

It is evident that the carapace just described represents a new form of *Discinocaris*, for which I propose the specific appellation of *D. Dusliana*, after Mr. Dusl, who first drew attention to the fossil.

Discinocaris Browniana, H. Woodw., differs from the Bohemian

species, firstly, by its circular outline; secondly, by the nuchal notch reaching backwards nearly to the centre of the carapace; thirdly, by the different slope of the nuchal suture.

The fauna of the "Colonie Haidinger" shows the same composition as the lowest Graptolitic horizon of stage E—e 1. The most common fossils of this "colony" being *Monograptus Becki*, Barr., and *Rastrites peregrinus*, Barr.

Having no sufficient materials, I will not discuss the question if the shields called *Discinocaris* should be regarded as opercula of Cephalopods or carapaces of Phyllopodiform Crustaceans; but it must be remarked that no trace of Cephalopods has yet been discovered in the "Colonie Haidinger."

III.—A New British Phonolite.

By Frederick H. Hatch, Ph.D., F.G.S.

(By permission of the Director-General of the Geological Survey.)

In working out, at the request of Sir Archibald Geikie, the petrography of the Lower Carboniferous Volcanic rocks in Haddingtonshire (the results of which I propose shortly to publish), I have been led to examine the igneous material that builds up the isolated hills (*necks*), situated on the margin of the volcanic area of the Garlton Hills. Among these, the rock of Traprain Law especially attracted my attention. It is a close-grained, dark brown to grey rock. Some varieties have a glistening or greasy surface, and are speckled over with dark spots, while others show glancing cleavage surfaces of a clear glassy felspar (sanidine).

The stone is quarried at the foot of the hill. On examining the broken material in the quarry, I noticed a tendency to split into rather thin plates. This "platy fracture," taken in conjunction with the fact that the stone has a remarkably sonorous ring under the hammer, and gives a metallic clink when small fragments are rattled together, might perhaps have suggested its real nature. But it was not until I had studied a series of thin sections that the true character of the rock became apparent, Microscopic examination shows that the rock is a *trachytic phonolite*, and thus adds another to the sparsely developed nepheline-rocks of the British Isles.

As I intend to describe this occurrence more fully elsewhere, I will confine myself in this place to a brief description. The rock bears no resemblance to the well-known phonolite of the Wolf Rock, described by Mr. Allport in 1871. It differs from that rock in the absence of members of the hauyn-nosean group, and by an inferior development of nepheline.

Instead of occurring in clearly discernible crystals, as in the Cornish rock, the nepheline of the Traprain Law phonolite is confined to small colourless to cloudy patches, or is interstitially wedged in between the felspar-lathes of the ground-mass. The satisfactory identification of nepheline when thus developed is the source of much trouble and vexation of spirit. Taking refuge in micro-chemical methods, I found that a drop of hydrochloric acid,

placed on a smooth surface of the rock, rapidly produced gelatinization, and that the jelly, when dried and treated with acetate of uranium, developed abundant characteristic crystals of the double acetate of uranium and sodium. The presence of a sodium-bearing mineral in the rock was thus placed beyond doubt. By treating a section with hydrochloric acid, and staining with fuchsine, after washing off the acid, the nepheline-patches were fairly well defined. Finally, to make quite sure of the matter, I sent a specimen of the rock to Professor Rosenbusch, of Heidelberg, who was good enough to have a very thin slice prepared, in which he succeeded in detecting the presence of small four- and six-sided sections of nepheline. Prof. Rosenbusch confirms my diagnosis of the rock, and refers it to the trachytoid division of the phonolites in his classification (*Physiographie der massigen Gesteine*, vol. ii. p. 622).

The main portion of the rock is made up of small lath-shaped crystals of sanidine, presenting in their mode of arrangement a marked micro-fluidal structure. Porphyritic crystals of sanidine also occur, but not very frequently. The only other constituent of any moment is a green augite giving high extinction angles. The presence of aegirine has not been detected. Apatite and sphene also occur in isolated granules. In the nepheline-patches the alteration of that mineral has given rise, as usual, to the formation of zeolites (analcime and natrolite).

Geological Survey Office, 28, Jermyn Street, S.W.
Feb. 20th, 1892.

IV.—Drift Coal in Sandstone.

By G. W. Bulman, M.A.,
Corbridge-on-Tyne.

THE most exclusive advocates of the hypothesis of the terrestrial origin of Coal admit that those small irregular patches, veins, and nests of the same occurring in beds of sandstone are formed of drift vegetation. And admitting this, it is difficult to draw the line until we have ascribed a similar origin to certain definite coal seams of considerable extent. Granting this much, however, is obviously a different thing from the belief that *all* coal seams are to be ascribed to drift vegetation; and while the following remarks are intended to show what a strong argument such drift coal in sandstone furnishes for the *probable* drift origin of *certain* coals, there is no intention of ascribing such an origin to *coal in general*.

Such drift coal in sandstone is of very common occurrence in the Coal-measures, and good examples are to be seen in the coast-section of the Northumberland coal-field. It seems strictly analogous to those similar patches of shale which are also common in sandstone, and the same origin must be ascribed to both.

The explanation in the case of the shale is, that the currents which brought the coarser material of the sandstone failed at intervals, and that consequently the finer sediment—which would otherwise have been carried further and laid down by itself—was allowed to settle in hollows among the coarser, and was in turn overlaid by it when

the currents regained their force. And we must suppose the same currents brought down vegetable matter, which, when their force failed, might be laid down among the coarser sediments, and would at other times be carried beyond and laid down by itself. The obvious inference is, that, as beds of pure shale are due to the same drift origin as the fragmentary patches in the sandstone, so, if we allow a drift origin for the fragmentary coal, we must also admit the probability of the accumulation of *beds* of pure vegetable matter by the same agency.

But as in the case of shale we find every gradation between included fragments in sandstone or shaly sandstone, and strata of pure shale, so—if the origin is the same—should we find a similar series of transitions in the case of coal. And such is, in fact, the case. For, as we have shaly, so we have carbonaceous, sandstones; and as we have shales intercalating with, and occurring as isolated masses of considerable extent in, sandstone, so we find it also in the case of coal.

In the Survey Memoir of the Yorkshire Coal-field some good examples of the complicated intercalations of shale and sandstone are given (see pp. 73 and 94). These are similar to the intercalations of coal and sandstone in connexion with one of the "rock faults" described and figured in the Memoir of the South Staffordshire Coal-field.

Reference to the sections (figs. 4 and 5) given on pages 184 and 185 of this latter Memoir shows the intimate connexion of the coal and sandstone. And, as Mr. Jukes remarks, even the minute veins of coal are "perpectly bright good coal." It is difficult to account for this purity combined with intimate intercalation on the theory of growth *in situ*, and the similarity to the intercalations of shale above referred to suggest for the coal a similar origin.

In the Coal-measures of Central France, again, M. Fayol describes numerous examples of the minute intercalations and interlaminations of the coal with sandstone and shale. In their intimate ramifications with the sedimentary deposits these portions of coal seams are strictly comparable to the intercalations of shale and sandstone of the Yorkshire Coal-field, and to the branching of the "Thick coal" in connexion with the "rock fault." And they form one of the arguments which have led M. Fayol to advocate a drift origin for the coal.

Such intercalations of coal and sandstone, then, while they form a difficulty on the hypothesis of terrestrial accumulation, are just what we should expect if we ascribe to the coal an origin similar to what we allow for the shale.

The purity of the coal—even in the thin veins—and its clear lines of demarcation from the sandstone can only be attributed to the sorting power of water; the hypothesis of floods carrying sediment over the edges of the swamp where vegetation was accumulating cannot account for this purity of the thin layers of coal; for the growth of vegetation after each flood would necessarily mingle itself with the mud, and be in turn thoroughly permeated by that brought

down by the next. But, admitting the drift origin of these intercalations, it follows that the "Thick coal" itself, of which seam they are portions, must be attributed to a similar origin.

Coal-seams may also be broken up by intercalated bands of sandstone, as in the following section of the "Kailblades" Coal of the Midlothian Coal-field:

	Feet.	Inches.
Sandstone and Shale	10	8
Coal	1	6
Sandstone	2	11
Coal	1	1
Sandstone and Shale	3	2
Coal	1	10
Sandstone and Shale	78	1

(Memoirs Geological Survey, Geology of the Neighbourhood of Edinburgh, p. 97.)

Similarly thin seams of coal may occur in beds of sandstone, as in the following section on page 100 of the same Memoir:

	Feet.	Inches.
Grey Sandstone	52	0
Coal	0	3
Sandstone	3	0

There are, moreover, certain areas of coal—usually of limited extent—which are attributed to drift vegetation by advocates of its terrestrial origin in general. Thus Prof. Green attributes the origin of cannel coal to the accumulation of drift vegetation in ponds or lakes:—

"The presence of fossil fish in cannels shows that they must have been formed under water, and they probably consist of vegetable matter which has drifted down into ponds or lakes and lay soaking till it became reduced to pulp" (Coal, by Professors Green and Miall, etc., p. 31).

And if it be admitted that the sand, mud, and vegetable matter drifted down by streams into the pond or lake were sorted so as to produce beds of more or less pure coal, is it not necessary also to admit that a similar sorting, on a much larger scale, would take place with the vegetation and other *débris* carried down to the sea?

Thus we are led to admit the possibility of more extensive beds of coal being formed of drift vegetation. Nor is it necessary to assume that such drift coal will necessarily be cannel. For the obviously drift coal we have been considering is not cannel, but ordinary bituminous coal, with the usual cleavage.

If, then, cannel coal—as seems probable—was formed by drift vegetation, and ordinary bituminous coal in sandstone has a similar origin, there seems no reason why areas of the latter as extensive as those of the former, or even more so, should not occur. Such a conclusion, however, leaves unexplained the differences between cannel coal and the ordinary bituminous coal found in sandstone.

Other considerations point to the conclusion that in certain cases ordinary bituminous and cannel coal have been formed under the same conditions as to place.

In the Northumberland Coal-field, for example, no distinct and

separate beds of cannel occur; it is only *portions* of seams of ordinary coal which furnish it.

In Scotland, again, a seam of coal 2 feet thick, and lying between two beds of limestone, has the upper 8 in. cannel (Geology of Neighbourhood of Edinburgh, Surv. Mem. p. 55).

It seems the natural conclusion to suppose that the two kinds of coal were formed in the same way.

Cannel coal, again, is found at times resting on an underclay like an ordinary bituminous coal. The well-known "Boghead" cannel, for example, is thus underlaid. And in the sections from the Coal-field of Cape Breton, given by Sir J. W. Dawson, on p. 414 of his Acadian Geology, four seams of cannel coal are given as resting on underclays. The presence of such underclays beneath coal seams is one of the main arguments in favour of the origin of coal *in situ*; and however we interpret it in this case, it is suggestive of a common origin for cannel and ordinary coal *in some cases at least.*

And as coal and shale are both found in irregular strings and patches in sandstone, so coal is found associated in the same way with beds of shale. Thus we find described in the Survey Memoir of the Yorkshire Coal-field "a section of strings of coal in shale about 1 foot long and 1 inch at the thickest, thinning out towards each end" (p. 579). And on p. 519 of the same Memoir we find the following section showing the same phenomenon in underclay:—

	Feet.	Inches.
Coal	3	6
Underclay and *Coal-veins*	0	8
Sandy Underclay	1	6
Sandy Shale...	1	9
Sandstone	2	0
Underclay and *Coal-veins*	4	1

And from this occurrence of veins of coal in underclay to the following section from the same Memoir, where the coal may be said to play the rôle of "partings" in a bed of underclay, is but a step:

	Feet.	Inches.
Coal	0	6
Underclay	4	1
Coal	0	1½
Underclay	2	2
Coal	0	4
Underclay	1	5
Coal	0	3

(High Moor Lane Pit, p. 167.) Between such a section as the above and the average coal-seam, where underclay or other fine-grained rock forms the "partings," the difference is again merely one of degree.

And similar patches and veins of coal are found not infrequently in limestone. Here, again, is coal obviously of drift origin, and as in the previous cases it is pure, bright, cleaved coal like that of the ordinary seams of the Coal-measures.

The fragments of coal in limestone lead to the consideration of the coal-seams associated with limestone strata, as in the Lower Carboniferous of Northumberland and Scotland. In Northumber-

land the coal is sometimes directly overlaid by a limestone, and rests with its accompanying underclay on a sandstone. We can scarcely suppose an abrupt transition from terrestrial conditions to those requisite for the formation of limestone; or, in other words, that the sinking area would not pass through the stage where sand and mud would be deposited on the coal. And there is a further difficulty in understanding how the terrestrial surface could be lowered to the requisite stage for the formation of limestone without suffering extensive denudation. A more probable supposition seems to be, that the shallow, near-shore, conditions which allowed the formation of a sandstone gave place gradually to the deeper water in which underclay, coal, and limestone were formed in succession.

Further examples of limestone directly overlying coal-seams may be cited from the Carboniferous Limestone Series of Scotland. Thus, Sir A. Geikie describes a limestone "of a compact bluish-grey texture, with abundant fragments of small encrinites," resting on "an eight or ten inch seam of coal" (Geology of Edinburgh, Surv. Mem. 32 Scotland, p. 48).

Again, a section given on p. 55 of the same Memoir shows a 2 feet seam of coal overlaid by 8 feet of limestone and resting on 3 feet of "Cement"—a kind of impure ferruginous limestone. It is interesting to note that the upper 8 inches of this coal is "Parrot" or cannel coal.

On p. 81 of the same Memoir Mr. Howell describes an exceedingly interesting case in which a coal-seam with its fire-clay occurs between two beds of limestone. The seam is not continuous, and the two beds of limestone sometimes come together.

Such a case would be extremely difficult to explain satisfactorily on the growth *in sitû* hypothesis, and it is not easy to resist the conviction that if the limestone was formed in moderately deep water, and some little distance from land, coal and fire-clay were also formed under approximately similar conditions of depth and distance from shore.

On the whole, then, it must be admitted that the occurrence of such fragmentary drift coal as we have been considering furnishes a strong argument that seams of ordinary coal *may, in certain cases,* have had a similar origin.

V.—Notes on the Ash-Slates and other Rocks of the Lake District.

By W. Maynard Hutchings, Esq.

WHILST studying the sedimentary roofing-slates of North Wales and Cornwall, and allied materials, my attention was also directed to those most interesting rocks, the ash-slates of the Lake District, often externally so closely resembling some of the Welsh and Cornish examples, though differing so much in origin. In course of time I have collected, and had sections prepared from, a considerable number of specimens from many quarries and other places at various parts of the district, both very fine-grained well-cleaved actual roofing-slates and also the attendant coarser beds.

A full understanding of the changes these deposits have undergone, and their present nature, would require a large amount of fuller study, especially in a chemical direction; but some of the results of my observations may be worth recording as far as they go, even if only on the chance that they may perhaps induce some worker, with more time and opportunity at his disposal than I possess, to take up the investigation of these rocks. In the Lake District we have a wonderful field for the petrological microscopist and chemist, which has been singularly neglected, I think, considering the avidity with which petrological work has been taken up of late years.

Perhaps this comparative neglect may be less seen in future, since the paper by Messrs. Harker and Marr on the Shap rocks has shown what splendid work may be done there by competent workers.

If we examine a series of the finer-grained rocks of the district, taking some of those worked as roofing-slates as especially typical, we find considerable variation in texture, corresponding to differences in composition as shown by the microscope. Thus the larger portion of such slates are seen, in thin sections under low and moderate powers, to consist of more or less well-defined and recognizable fragments and grains of various kinds,—lapilli, felspars, calcite, chlorite, etc.,—bedded in and surrounded by varying amounts of a paste, or base, so to speak, which is exceedingly fine-grained. This very fine-grained material increases in some slates till it becomes the sole constituent, while in others it plays only a more subordinate part; but it is always present and always, within certain limits, similar in appearance under the microscope, till we pass over into the coarser-grained ashes and tuffs which are not classed as slates at all.

In order to study the nature of this pervading "base," I will select one or two special occurrences, in which the original nature of the materials from which they have been formed can be ascertained with considerable certainty.

There is an old quarry in the valley of Mosedale, near Shap, in which beautiful examples of these ash-slates occur. Bands of various coarseness of grain succeed one another in narrow limits and pass abruptly into one another, corresponding, apparently, to sudden changes in the condition of the volcanic detritus being deposited. A coarser band, for instance, will consist very largely of good-sized lapilli, sharply outlined and well preserved, formed for the most part of normal andesitic rocks of the district, but with rhyolite also represented, and will contain also many detached crystals and fragments of felspar, with varying amounts of grains of calcite and patches of chlorite.

A succeeding fine band will show none of these lapilli, recognizable fragments of felspar, etc., but consists absolutely of the very fine base which surrounds the lapilli, etc., in the coarser band. We cannot doubt that it represents the alteration-product of the very finest dust of the same materials as make up the coarser band, and therefore that it consisted originally mainly of andesitic and felspathic powder with a little rhyolite intermixed.

It is very difficult to make out much as to its exact nature under the microscope; nothing but the very thinnest films are of any use. Taking the thinnest edges of thin sections, or the margins of little holes worn in the last stages of grinding, and studying these carefully with a $\frac{1}{4}$ or $\frac{1}{8}$ objective and good illumination,[1] the most prominent constituent is seen to be a very pale-green chlorite in a felted mass of extremely minute flakelets, mainly arranged flat in the plane of cleavage. In polarized light one sees large numbers of minute rod-like bodies lying in all directions in among the chlorite, strongly bi-refractive, extinguishing quite parallel, their long axes being axes of least elasticity. In ordinary light these rods are not seen at all. There are also countless minute grains of another mineral, mainly so small that, owing to the very high refraction which they possess, they appear as opaque bodies; but larger ones occur with transparent colourless to yellow centres. These grains are so numerous that the whole slide, under low power, seems simply full of a dark dust. The largest grains attain to a diameter of about $\frac{1}{12000}$ inch. By examining such of these larger grains as occur at spots in the slide which remain dark on rotation between crossed Nicols, it is seen that they are isotropic.

On rotating the section in polarized light, the whole appears as a faintly-speckly, cryptocrystalline, felsitic-looking mass, full of the brightly-polarizing minute rods above spoken of, and one suspects that there is some other matter present besides those mentioned, but it is so wholly enveloped in and masked by the chlorite that nothing can be safely made out.

If a thin section is treated alternately with hot hydrochloric acid and solution of caustic potash, the chlorite may be mostly removed; but this operation succeeds better using powdered slate, digesting thoroughly with moderately strong acid, washing free from the dissolved chlorides and treating with hot potash solution to remove separated silica, afterwards mounting the small grains and flakes in balsam. Material so prepared is free from chlorite and reveals

[1] In the matter of illumination, I have for a long time given up attempting to work by daylight, which in this climate is usually of too inferior a quality and too capricious for anything but low-power work. After experimenting in various ways I now make use of an ordinary good microscope-lamp burning paraffin. The lamp-chimney is of pale-blue glass, and the bull's-eye condenser used with it is also blued, by cementing to the flat side of it, with Canada-balsam, sufficient thicknesses of pale-blue glass so that the field of light obtained in the microscope appears bright white, like the *best* daylight. The adjustment of the quality of the light can also be controlled by observing the colours in polarized light of several points on a quartz-wedge (or better, on a mica-wedge made as recommended by Mr. Dick) first in good daylight and then in the light of the lamp. The depth of blue glass added to the condenser should be such that the colours are exactly the same in both cases. Then, with a good full flame and using the broad side of it, the light should be so thrown on to the mirror, from the flat side of the condenser, that the mirror is just covered with light. The effect in the microscope is the same as working with an exceptionally fine sky and one is sure that one's work will not be spoilt by a change in the light. Anybody who has once got used to working in this way and to the great advantage of always working with the *same* light will not again forego its advantages, but will, even in the daytime, make exclusive use of artifical light. My own experience also is that work with a good steady *white* light of this sort is less trying to the eyes than anything else.

much more of its nature. The dark granular matter, enlarging into transparent grains, is still present in the same abundance as before. Its isotropic character is now more easily ascertained. Taking its various characteristics as stated, together with the fact that no amount of boiling in strong acid affects it, there is no reason to doubt that this granular mineral is garnet. It is far too minute to allow of any mechanical separation of it. The brightly-polarizing rods are also present as before, and it may now be made out that they are the transverse sections of minute flakes of a faintly yellowish to greenish mica, apparently a "sericite" in all respects analogous to the minute mica of the fireclays and sedimentary slates.

This mica and the garnets are seen, especially on rotation in polarized light, to be intimately mixed in with some other substance, whose exact nature cannot be determined. There is a very minute mosaic of low polarization-tints, partly due to such of the mica as lies more or less flat in the field, but in which one is led to expect also quartz or felspar, or possibly both. More or less of the component grains of this mosaic show faint dark crosses, due to spherulitic structure, as of chalcedony.

A proper quantity of powder of this slate having been carefully prepared in the above manner with acid and caustic potash (especial care being taken to wash out the last traces of the potash), was dried at 110° C. and a very careful analysis has been kindly made for me by my friend Mr. George Paterson, of Liverpool, to whom I am much indebted for the great trouble he has taken in making this and the following analyses for me.

Silica	=	69·22	per cent.	
Alumina	=	15·70	,,	
Ferric Oxide	=	5·20	,,	(Includes a good deal of undetermined ferrous oxide,—hence excess in the total.)
Lime	=	1·45	,,	
Magnesia	=	1·80	,,	
Potash	=	4·90	,,	
Soda	=	trace		
Water	=	2·95	,,	
		101·22		

A consideration of this analysis shows at once that a large amount of free silica is present. It is, perhaps, not of much use to calculate the mineral-composition, even approximately, from the above figures, because we do not know the constitution of the sericitic mica, which is probably more complex than normal muscovite, and contains lime, magnesia, and iron.

Assuming, for the sake of argument, that its composition is similar to that of muscovite (Tschermak's formula), and that all the potash of the analysis is in the mica, then the alumina required would be 16·06 per cent. as against 15·70 shown by the analysis. But then there is the garnet to provide for, and we have no safe basis on which to calculate its composition. It is probably a lime-iron-alumina garnet. Also there may be felspar present finely diffused in the mosaic. All that we are able to say with safety is, that after removal of the abundant chlorite from this slate we have remaining

a mixture which would correspond, in round numbers, to something like 50 per cent. of sericitic mica and garnets, and 50 per cent. of free silica in the form of quartz with apparently some chalcedony. In some slides the minute quartz-mosaic expands and gets coarser at places, when its nature is more easily made out. Felspar is not usually distinguishable in it. We may look upon it that the original andesitic and other volcanic dust of the rock has decomposed in such manner that the augite and other ferro-magnesian constituents gave rise to chlorite with garnet, while the felspathic part of the mixture was largely altered to mica.

It is pointed out by Tschermak (Mineralogie, third edition, p. 467) that during the alteration of potash-felspar to mica, a large part of the silica is liberated, together with the greater part of the potash in the form of silicate. Rosenbusch also points out the same thing, and shows that soda-lime felspars undergo a similar change, which, however, then involves also a separation of lime as calcite (Microscop. Physiographie der Mineralien, pp. 516, 543).

The silica thus liberated accounts for the finely diffused quartz (and chalcedony) above described, while calcite, also due, doubtless, in part to the same processes in the felspars, abounds in all these rocks. Some of the very fine-grained bands may be seen almost free from it, as is the slate we are just now considering; but it has then been deposited all the more copiously in the alternating coarser bands.

Whether in these cases of mica-formation in plagioclase-felspars the resulting mica is sometimes largely soda-mica (paragonite), or is due only to the potash which is so usually contained in these felspars, does not appear to have been ascertained. It would be very difficult, if not impossible, to get decisive chemical evidence. It seems reasonable to suppose that in some cases, at any rate, paragonite will be formed in a manner precisely analogous to the production of muscovite. So far as this Mosedale slate is concerned, however, the analysis appears to show that paragonite is not present. All analyses of Lake District andesites show a notable percentage of potash, which there is good reason to suppose is mainly contained in the felspar and glass of the ground-mass, and the ashes and tuffs mainly contain also more or less of rhyolitic, and possibly trachytic, fragments.

Garnets are alluded to as present in some of the Lake rocks by Mr. Ward and by Mr. Sorby, but in both cases, as far as I understand it, in a larger form. I do not know that its presence so finely disseminated and in such abundance has been pointed out. Slates like these at Mosedale, full of minute garnets, occur also at many other parts of the district, and it has occurred to me whether some of them might not have good qualities as whet-stones conferred upon them by the presence of this mineral. The celebrated "coticule" of Viel Salm is considered to owe its virtues to the garnets contained in it; these are, however, very much larger than the largest of the grains in the Mosedale slates.

The "base" of the slates is not all garnetiferous. It often

occurs, both by itself and in mixture with coarser matter, quite free from garnet-grains, but in other respects exactly the same as just described. An example of this may be taken from the old quarries at the top of Kentmere Valley, a little below the reservoir. Some of the slates here are of the utmost fineness and smoothness and in outward appearance could not be distinguished in any way from some Welsh sedimentary slates.

The microscope shows the same intimate mixture of chlorite, mica, and ultra-fine quartz-mosaic, but free from garnet. A sample prepared as before was analyzed by Mr. Paterson with the following results:—

Silica	=	74·58 per cent.	
Alumina	=	11·22 ,,	
Ferric Oxide	=	4·88 ,,	(Ferrous oxide not determined.)
Lime	=	1·60 ,,	
Magnesia	=	2·00 ,,	
Potash	=	2·83 ,,	
Soda	=	0·55 ,,	
Water	=	2·45 ,,	
		100·11	

We see here that silica is in still greater abundance, and that soda has not so fully disappeared, which perhaps partly corresponds to the fact that some few small grains of clastic felspar are still discernible in the specimen from which this analysis was made, the material having been a trifle coarser than the Mosedale specimen, in which no such grains now remain. The soda may also be here partly in the mica, or there may be also regenerated felspar in the mosaic.

The above two occurrences of fine-grained slate were selected partly for the reason that from among many examined they seemed, on microscopic examination, to be the most highly micaceous and most completely altered, and the subsequent analyses bore out this selection. Another instance may be given of a very fine-grained slate (from a quarry at Grasmere), which gives chemical results differing considerably from the former ones. Under the microscope just the same things are seen as in the Mosedale slate. It differs in containing more chlorite and a good deal of finely-disseminated calcite; and it is rather less micaceous. After extraction with acid and potash as before, just the same sort of material remains behind, the garnets being rather larger than at Mosedale.

A sample was prepared, half of which was extracted as before, and the original and extracted portions were taken by Mr. Paterson for determination of silica and alkalies, the following figures being obtained:—

A. Original.				*B. Extracted.*		
Silica	= 61·75 per cent.			77·40 per cent.		
Potash	= 0·85 ,,	} 6·34 p.c.		2·40 ,,	} 7·27 p.c.	
Soda	= 5·49 ,,			4·87 ,,		

Looking first at analysis B., we see that a very large amount of soda is present as compared with the Mosedale and Kentmere cases. The potash-percentage is not very different from that at Kentmere.

Comparing A. and B., the most striking fact is that though the removal of the chlorite and calcite has tripled the potash-percentage in the residue, the soda has not only not kept pace with it, but has actually diminished, so that much the greater part of it has been removed by the digestion with moderately strong acid.

As regards the form in which the soda is contained in these samples, it is not possible to make any definite statement, as the microscope does not assist us. There is hardly a trace of clastic felspar to be identified; how much may be present as minute dust still, or as secondary material in the fine mosaic, cannot be ascertained.

The solubility of so large a part of the soda may be explained in two ways. Zeolitic minerals exist in these rocks, and though nothing can be made out microscopically in this instance, there may be a considerable amount of soda-zeolites finely disseminated.

There is another explanation which may not improbably be combined with the above, viz. that this particular band of slate was formed from an ash much more basic than in the case of the Mosedale and Kentmere bands. It may be noted that the most basic rock hitherto observed in the Borrowdale series occurs near Grasmere (Geol. Mag. Dec. 1891, p. 538), and some of the coarser ashes in the neighbourhood also point to basic rocks. The fine slate now under consideration is traversed by bands of coarser material. One of these, within an inch from where the material for analysis was taken, though obviously originally composed largely of lapilli, is now almost wholly made up of grains of chlorite and calcite, pointing to rocks more basic than the usual andesites as having been largely among the components. The finest dust of such material would contain more labradorite, or other basic felspar, than do the andesites. The removal of much calcite and iron in solution, during decomposition of the augite, etc., of such dust, would cause a relative enrichment as to silica and alkali (A. is richer in alkali than most ashes and other rocks in the district). Finally, alteration of the fine ash may be here less complete than in the cases previously dealt with, and there may still be some labradorite, etc., present, finely divided, and attacked during digestion in acid.

Of the soda which remains in B. some part may be in the mica, and a part—probably the larger part—as felspar. Some of this felspar may be original dust of more acid felspars, but it is more likely that it is in the form of "regenerated" felspar in the mosaic with the quartz and mica. Examination of the coarser ashes and tuffs, as well as andesites, of this district, shows the regeneration of felspar (albite, andesine?) to be most abundant and widespread (see further on), and though the microscope is not able to demonstrate it in the very fine-grained mosaic of this "base" of the slates, it is quite reasonable to suppose that such regeneration has in some cases taken place there also, under the same conditions of chemical change and intense dynamic action.

At any rate, whatever be the correct explanation of the chemical facts as to this particular slate, we see that, taking these rocks as

a whole, the processes which have gone on are complex and diverse, and that the microscope is even more than usually in need of chemical aid in attempting to interpret them.[1]

(*To be concluded in our next Number.*)

VI.—The Age of the Himalayas.

By W. T. Blanford, LL.D., F.R.S., etc.

WHEN a case is hopeless, there are two recognized ways of ignoring the fact, and yet of appearing to reply to an adversary. One is the legal device commonly known as 'abusing the plaintiff's attorney,' the other is the equally familiar method of replying to something that the opposite party did not say. The latter has been preferred by my friend Mr. Howorth in his paper on "The Absence of Glacial Phenomena in large parts of Western Asia and Eastern Europe," published in the February Number of the Geological Magazine, pp. 54–64, as the following instances will show.

(1) In the August Number of this Magazine for last year (p. 373), I contended that the salt plains of Central Asia afford no proof of the former occupation by the sea or by extensive lakes of the depressions in which salt now collects. I said, however, that the evidence afforded by similar plains in Persia appeared to me at one time so strong that I was led away by it and mistook them for ancient lake-basins. These remarks of mine, which, as any one may see by referring to them, relate solely to the salt plains. are applied by Mr. Howorth to the observations of Humboldt, Tchihatcheff, Von Cotta and Severtsof on the absence of glacial phenomena in the Urals, Altai Mountains, and Thian Shan range. I thought I had especially guarded myself against being drawn into a discussion about mountains concerning which I know nothing; and I must protest against words of mine relating to one part of the argument, the salt plains, being applied to a distinct subject, the glacial phenomena on mountain ranges. To prevent any mistake, I may add that the circumstance of my declining to discuss any question about these ranges by no means implies that I admit either the accuracy of the views quoted, or of Mr. Howorth's deductions from the quotations.

(2) I pointed out that Mr. Howorth's argument about the Himalayas appeared to be this: that if the Himalayas existed during the

[1] It is interesting, in connexion with these fine-grained ash-slates, to refer to the "altered ashes" in the contact-zone of the Shap granite, as described by Harker and Marr. The intimate mixture of chlorite, mica, and quartz gives rise to the much larger mosaic of quartz and biotite. The quartz is converted into much larger individualized grains. The sericitic mica is absorbed into the biotite, as is so usually the case when sedimentary slates are altered by granite-contact. The finely-disseminated garnet (if originally present in the ashes at Shap) is apparently also re-absorbed during these processes, as I have sought for it in vain in many Shap sections.

In the mosaic of these Shap contact-rocks felspar is sometimes seen, sometimes not, which fact rather lends support to some of the inferences I have drawn as to the interpretation of the analytical results.

Glacial epoch, the Himalayan glaciers would have invaded the plains of India, just as the Alpine glaciers reached the plains of Lombardy; and I said that this was precisely equivalent to arguing that the glaciers of the Alps at the present day ought to descend to the sea-level because those of Greenland do so, the difference in latitude between the Himalayas and Alps being about the same as that between the Alps and Greenland. Mr. Howorth says he does not quite understand the reference to latitude; he asks what latitude has to do with the question, and then proceeds to a disquisition about the Urals, Altai Mountains, and Northern Rockies. I decline to complicate the question by dealing with these mountains. Mr. Howorth says it is not latitude that has to do with the question, but an abundant supply of moisture and a sufficiently powerful source of cold. I can only conclude from this that, in Mr. Howorth's opinion, the temperature of the earth's surface does not vary with the latitude, or did not in the Glacial epoch, and that the distance from the Equator has no relation to the "source of cold." I quite admit the importance of an abundant supply of moisture in the production of glaciers, and I believe the reason that no glacial markings are to be seen on some mountains is simply due to want of sufficient snow.

(3) By far the best example of a reply of Mr. Howorth's to something that I did not say is in the case of the Tibetan Rhinoceros. I said (p. 374), "where Yaks can find food, there is no reason why a Rhinoceros should not obtain subsistence." I also pointed out that the remains of *Pantholops*, an antelope now peculiar to high elevations in Tibet, occurred with those of the Tibetan Rhinoceros, and I asked if it were more likely that *Pantholops* formerly inhabited a low level or the Rhinoceros a high one. These two arguments Mr. Howorth says he does not quite follow, and, to show that he does not, he understands me to say, "that because the Wild Ass and the Antelope can live now at great heights, the Rhinoceros could do the same."

This is really a stroke of genius. It is almost a pity that Mr. Howorth, having set up so beautiful a man of straw, should have been tempted by the bad example of his predecessors in the art, into dealing with his creation as it has been customary to deal with men of straw from time immemorial. For in his song of victory over his discomfited puppet, he deals with subjects concerning which his acquaintance is somewhat imperfect. He informs us, for instance, that the Rhinoceros is a tree-feeding and shrub-feeding animal, which is startling, as two of the five species now, or very recently, existing, namely, *R. simus* and *R. unicornis*, live, or lived, chiefly, if not entirely, on grass, and then he adds that "we know the kind of trees which the *Rhinoceros antiquitatis* fed upon," which is perfectly true, but has nothing to do with the food of the Tibetan Rhinoceros, for whatever the latter may have been, it was assuredly not *R. antiquitatis*, nor had it any near affinity to *R. antiquitatis*. A reference to the "Catalogue of Fossil Mammalia in the British Museum" (vol. iii. p. 158) will show that the Tibetan Rhinoceros was closely

allied to a species belonging to *Aceratherium*, a small hornless (extinct) group, with well-developed incisors in both jaws. *R. antiquitatis*, as is well known, was a huge two-horned animal without, or almost without, incisors.

Nor is this all. We know that *R. antiquitatis* fed on certain trees (I believe it ate grass also, but this is immaterial), but we also know, not from the examination of teeth belonging to two or three skulls, but from numerous observations on the wild animal, that the nearest living (or recently living) ally of *R. antiquitatis*, the so-called White Rhinoceros of South Africa, *R. simus*, feeds or fed entirely on grass (see, for instance, P.Z.S. 1881, p. 726), so that any inference as to the Tibetan Rhinoceros being a tree- and shrub-feeder, from what is known of the food of *R. antiquitatis*, would be worthless, even if the two species were closely allied, instead of belonging, as they do, to very different sections of the genus.

Again, we are told by Mr. Howorth that the Rhinoceros does not graze on short grass. From the context it may be fairly inferred that the grass of Tibet is regarded as short. Now 'short' is a relative term; various members of the family of grasses vary in length from two or three inches, or even less, to 20 feet at least (without including bamboos). But if by short grass Mr. Howorth understands turf, such, for instance, as is found on most English hills, I can only say that the Tibetan grass, which is described by Kinloch as coarse and wiry, grows in tufts amongst stones, and does not deserve the term. Moreover, as Lydekker has shown (Records Geol. Surv. India, vol. xiv. 1881, p. 183), there is a considerable amount of low bush and other vegetation besides grass on parts of the Tibetan plateau. I believe the whole argument was completely covered by what I urged before, that where a large bovine like the Yak can find subsistence, a Rhinoceros (and especially a Rhinoceros no larger than a Yak) can do the same.

Mr. Howorth also says he does not understand "why the existence of a zoological sub-province in China, which has been established by a chain of observers from Brian Hodgson to Père David, precludes the notion, otherwise so strongly supported, that the Highlands of Eastern Asia are a recent feature in physical geography." Here the fault may have been mine in not explaining my argument more clearly, though in cases where I thought I was thoroughly explicit, Mr. Howorth, I regret to say, finds great difficulty in following my reasoning. The point is one of considerable interest, and I may perhaps be allowed to explain it more fully.

In the first place I must explain that my remarks on the fauna of Tibet do not refer to the zoological sub-province in China, by which of course Mr. Howorth understands the Indo-Chinese sub-region of Wallace, comprising the Himalayas and Southern China. Both Brian Hodgson's and Père David's collections were chiefly composed of specimens belonging to the fauna of this sub-region, which is part of the Oriental or Indian region. But both these collections contained a few gleanings from the true Tibetan fauna which belongs to the Palæarctic region, and contains scarcely any Oriental forms.

Wallace, in his "Geographical Distribution of Animals" (vol. i. p. 216), did not distinguish the Tibetan fauna from the Siberian. Hodgson wrote a paper on the Mammals of Tibet in 1842; but this list is naturally imperfect, whilst some of the species enumerated are not Tibetan. I gave a somewhat fuller but still very imperfect list in 1876. I have drawn up the following list of known Tibetan Mammals from various sources, several additions having been made by Büchner in his description of Przewalski's collections from Northern Tibet. The limits of Tibet, as I understand it, are the Himalayas on the south, the Kuenlun, Altyn Tag and Nan-shan on the north; and the plateau extends from Ladak to Koko-nor inclusive, and probably comprises part of Kansu in China. No part of the plateau, so far as is known, is less than 12,000 feet above the sea; but of course our information about the region is still imperfect.

Mammalia of the Tibetan Plateau:

Insectivora.

Crocidura aranea.
†*Nectogale elegans.*

Carnivora.

Felis manul.
F. lynx.
F. uncia.
**Paradoxurus laniger.*
Canis lupus, var. *laniger.*
Vulpes alopex, var. *flavescens.*
**V. ferrilatus.*
Cyon Deccanensis, var.
Mustela foina, var.
**Putorius larvatus.*
**P. canigula.*
P. alpinus, var. *temon.*
P. erminea.
**Meles leucura.*
**M. albogularis* ?
†*Æluropus melanoleucus.*
Ursus arctos, var. *pruinosus.*

Rodentia.

†*Eupetaurus cinereus.*
**Arctomys Himalayanus.*
**A. robustus.*

Rodentia—*continued.*

**Mus sublimis.*
**Microtus* (*Arvicola*) *Blythi.*
**M. limnophilus.*
**M. Strauchi.*
**M.* (*Eremiomys*) *Przevalskii.*
Siphneus Fontanieri.
**Lagomys Curzoniæ.*
**L. rutilus.*
**L. erythrotis.*
**L. melanostomus.*
**L. Ladacensis.*
**Lepus oiostolus.*
**L. hypsibius.*

Ungulata.

Equus hemionus, var. *kiang.*
**Bos grunniens.*
**Ovis Hodgsoni.*
O. Vignei, var.
**O. nahura.*
Capra Sibirica.
†*Panthlops Hodgsoni.*
†*Budorcas taxicolor* ?
**Gazella picticaudata.*
**Cervus affinis* ?
Moschus moschiferus.

In this list * signifies a peculiar species, † a peculiar genus, that is a species or genus not known to exist out of Tibet. It will be seen that out of 46 species in the preceding list three are marked with a note of interrogation. In the case of one of these, *Meles albogularis*, the locality is not I think clearly ascertained, and there is a possibility that neither *Budorcas taxicolor*, nor *Cervus affinis*, is truly Tibetan, though the first, at all events, is probably so. It should also be added that several of the forms, such as *Canis laniger*, *Putorius temon*, *Ursus pruinosus*, *Equus kiang*, here classed as varieties of widespread types, are by many naturalists regarded as peculiar species, and *Bos* (*Poëphagus*) *grunniens* and *Gazella* (*Procapra*)

picticaudata as peculiar genera. But omitting all doubtful forms, and taking no account of varieties or subgeneric types, it will be found that in the preceding list of 43 species, 27 are peculiar, and of 26 genera, 4. So far as I am aware there is no other instance in the world of a continental area of the size of Tibet that contains an equally peculiar Mammalian fauna. It should also be remarked that by far the largest proportion of species ranging beyond Tibet is exhibited by the Carnivora, which are great wanderers, and that among the Ungulates, wide-ranging forms as a rule, only four species out of nine (omitting *Budorcas* and *Cervus affinis*) are found elsewhere, two at least of these four being represented in Tibet by well-marked varieties. Of the Rodents, 16 in number, only one species is known to range into other parts of Asia. The solitary Oriental (Indian or Indo-Chinese) species in the whole list is *Cyon Deccanensis*, the so-called Wild Dog of India, which, strange to say, does occur on the Tibet plateau, whilst the Siberian representative of the genus, *C. alpinus*, is absent. In other respects the affinities of the Tibetan mammal fauna are distinctly Palæarctic.

I have said that so far as I am aware no other continental area of the same size with an equally distinct fauna is known. For similar examples of specific and generic distinction we must look to islands. The difference, for instance, between the Mammalian fauna of Madagascar and that of Africa is far greater than that between the Mammals of the Tibetan plateau and those of other parts of Central and Northern Asia; whilst the differences between such Malay islands as Sumatra, Java and Borneo, or between any of them and the Malay Peninsula, is much less. On the whole the greatest similarity to the Mammalian relations of Tibet is presented by the island of Celebes, provided the Australian affinities of a minority of the Celebean Mammals be neglected.[1]

The view is, I believe, generally accepted that the difference of the fauna of any island from that of the nearest land is due to isolation of greater or less duration; and if the theory of evolution is accepted, and it is admitted that the different forms of Mammals, whether nearly or distantly related, have a common origin, it is a reasonable conclusion that the amount of difference between the forms inhabiting two neighbouring but separated areas has a distinct relation to the time that has elapsed since the areas were isolated from each other; those tracts in which there is a generic difference having been longer separated than those in which the distinction is only specific.

Thus it is probable that the separation of Borneo, Sumatra and Java, from each other and from the Malay Peninsula, is not older than Pleistocene or Newer Pliocene, the isolation of Java being of somewhat earlier date than that of the other two islands. The separation of Celebes from the rest of the Oriental region must be more ancient, and in "Island Life" Wallace suggests that it may date back to Miocene times. Bearing in mind that the isolation of

[1] They are probably of later introduction than the Mammals with Oriental affinities.

the Tibetan plateau is far less perfect as regards Mammals than that of any island, and that some of the forms—the Carnivora especially—found in Tibet are probably very recent immigrants, it is a reasonable conclusion that the peculiar fauna of the Tibetan plateau has been distinct from that of neighbouring countries since Middle Tertiary times.

But what has caused the isolation of the Tibetan fauna? Why, in this one continental tract is there a generic and specific differentiation of the Mammalia of which no other example exists? There is only one character in which Tibet is different from other continental areas, its great height. This alone renders the climate of Tibet so different from that of other parts of Central Asia, which are equally cold and barren. It seems a reasonable inference that the elevation of the Tibetan plateau dates back to Middle Tertiary times.

It is of course probable that the elevation was gradual; and although the area may have been sufficiently high at the close of the Miocene period to produce a difference in climatal conditions, the greater part of the upward movement may have been post-Miocene, and a great part post-Pliocene.[1]

I hope I have succeeded in making myself understood. I do not expect Mr. Howorth to concur; in all probability he has no more faith in evolution than he has in subaerial denudation, and will prefer to attribute the origin of genera and species to the same unknown agency as that which he supposes to have produced the river valleys of the Himalayas.

But really arguing with Mr. Howorth is hopeless work. I thought if there was any one point that I had clearly shown it was that the late Mr. J. Campbell's evidence as to the absence of glacial action in the Himalayas was worthless. Mr. Campbell never went near the higher Himalayas, and he himself compared his distant view of the Sikhim mountains from Darjiling to the look-out upon the Alps from the church tower of Novara in Lombardy. This and his other opportunities of seeing the higher Himalayas, might fairly be regarded as similar to those of a Swiss tourist, whose knowledge of the Bernese Oberland is confined to a view of it from the Rigi. Would Mr. Howorth accept the opinions of the Rigi visitor as to the presence or absence of glacial action in the Rhone Valley?

Mr. Howorth quotes two "experienced observers," Mr. Campbell and General MacMahon, whose testimony is decidedly at issue with mine and who have visited "the country" (p. 55). Now "the country" can only be the tracts "high up in the Himalayas" mentioned in the previous paragraph. I can only repeat that Mr. Howorth is in error in supposing that Mr. Campbell visited the higher Himalayas. With regard to General MacMahon's evidence, I regret I did not reply before; but all I can say is this: that I think Mr.

[1] In my last contribution to this question in the August Number of this Magazine, there is a mistake, that I must have overlooked in the proof, on p. 373. I wrote: "Surely to say that 'a movement has been distributed over the Tertiary and post-Tertiary period and a great portion is of post-Pliocene date,' is not the same as to say that the whole movement, or even the greater part of the movement, is post-Pleistocene." The last word has been by mistake printed post-Pliocene.

Howorth would have done wisely either to avoid quoting General MacMahon or else to give the whole of his evidence and not merely the few extracts which are in favour of Mr. Howorth's thesis. For although in his "Notes of a Tour through Hangrang and Spiti," General MacMahon remarks on the paucity—not the absence—of old glacial markings, in another paper "On the Geology of Dalhousie in the North-western Himalaya" (Rec. Geol. Sury. India, vol. xv. p. 49), he gives an account of moraines and ice-marks on the outer ranges at an elevation of only 4700 feet above the sea, and thus absolutely contradicts Mr. Campbell on the only point concerning which the latter's evidence was valid, the presence of glacial markings on the lower Himalayan spurs. Why is this important observation ignored? an observation not by a mere visitor like Mr. Campbell, but by an officer who long resided on the spot and had exceptional opportunities for careful observation?

A little consideration will show that General MacMahon's notes on Spiti agree with the observations in other high Himalayan valleys in showing that the glaciers during the Glacial epoch descended considerably below their present level. General MacMahon especially notes that the Spiti valley itself at an elevation of about 11,000 feet appears to have been moulded by ice. Naturally the question that occurs is—What is at present the mean level to which glaciers descend in the Spiti valley? Strange to say, although the ranges that surround the valley rise to 19,000 or 20,000 feet, there are no glaciers at all on the Spiti side except (as General MacMahon tells me) a very small one just inside the Bhabeh Pass. It is clear that in this case the ancient glaciers descended far below the level at which glaciers can now exist. And it is only right to add that 11,000 to 12,000 feet, the lower limit, according to General MacMahon, of the ancient glaciers in the Sutlej valley, is considerably below the level to which any now descend, so far as I am aware, in any part of the Himalaya.

In concluding these remarks, which have extended to an inordinate length, partly because hitherto, when I endeavoured to compress my arguments, I have unfortunately failed to make myself understood, I may briefly point out that, whilst I have accepted battle on Mr. Howorth's ground, and fairly met the arguments he has brought forward, he has never attempted to deal with the data on which the geologists who have devoted most time and study to the Himalayas have been led to the conclusion that these mountains were undergoing elevation throughout a great part of the Tertiary era. The questions of the glacial evidence, and of the Tibetan Rhinoceros, are side issues, and although I believe I have shown that Mr. Howorth is in error in both instances, and only appears to have made out a case because he has left out half the evidence, yet both might be decided in his favour without necessarily involving the recent origin of the Himalayas. Almost any hypothesis may be rendered plausible by ignoring the principal arguments that are opposed to it, and by selecting from the works of various writers a series of extracts that appear to tell in its favour. If, for instance, any one wishes

to demonstrate that the earth is flat, he will, I think, not find it difficult to support his contention by evidence similar in kind and equal in force to that by which Mr. Howorth has attempted to prove "the very recent and rapid elevation of the Himalayas."

VII.—Replies to various Criticisms.

By J. F. Blake, M.A., F.G.S.

THE criticisms which appeared in the January and February Numbers of the Geological Magazine, on certain writings of mine, require some reply. It is obvious that when an author ventures in any way to question or remark upon the results of others, he must expect their opposition to his statements. I have to offer a general apology to all authors on whose writings I have ventured to make critical remarks in the "Annals of British Geology," that I was unable to send them proofs of the articles before publication, as I hope to do in future, as long as the work is continued. In that way misunderstandings would be avoided. However, I must now proceed to business.

1. General MacMahon complains that a passage put in inverted commas is not his. It should not have been *all* put in inverted commas, I admit, yet I cannot see that it involves any misrepresentation of his views. The removal of silica spoken of cannot be thought to refer to the *two molecules* of olivine dealt with, as that would spoil the equation, but, as the statement is said to be thus brought into harmony with Roth's, it must refer to the additional half molecule, or the fifth if we start with four. So far from saying Gen. MacMahon's account must be wrong, I tried to point out how it really agreed with Roth's, though it appeared to differ. To use the General's illustration, if the son had received a *cheque* for one pound, and could only get 16*s*. cash for it, which he spent, his outing, though the items in his account only amounted to the latter sum, would still cost his father a sovereign. If every four molecules *converted into* serpentine involve the breaking up of a fifth, then it requires five molecules to *produce* two of serpentine. I am sorry that Gen. MacMahon has not availed himself of the chance I offered him, of giving us the calculation about the volume involved.

The question I asked as to why the infiltrating water does not alter the outside of a mineral, on its passage to the centre, is satisfactorily answered, provided, of course, (1) that increase in basicity in a mineral of the same general composition renders alteration easier; (2) that minerals whose centres decay first show a zonal structure, and, if this be applied to olivine, that that mineral should be zoned; (3) that corroding agents in contact with slightly varying material do not act on the several parts in proportion only to the ease of doing so, but leave the more difficult untouched till the other is all consumed. Is all this well known to be true?

There can be no doubt that, as Gen. MacMahon says, water, or at least its chemical elements, finds its way into the heart of minerals; but does it do so as water? and does it occupy intra-molecular

spaces? This, however, I have not ventured to discuss, but only to criticize the actual arguments brought forward in this connexion. I wrote "*sic*" after the word atoms partly because it sounded so funny to read of the "atoms *and* molecules of which minerals are composed," which is like saying that a sentence is composed of letters *and* words, and partly because I was not sure whether the phrase was a mere redundancy, or whether it was actually intended to be stated that heat enlarged the distance between the atoms in a molecule. This may be the case for all I know, but I do not think it can be quoted as a generally admitted fact. General MacMahon will thus see that his somewhat cruel inference as to why I wrote "sic" is not corrrct.

My illustration about hydrate of sodium sulphate is more to the point than Gen. MacMahon appears to think—the gist of it is that it gives an example of dehydration by heat in the *presence* and not "in the absence of water." General MacMahon says he was considering capillary flow under heat and *pressure*, but in the paper he really only discusses the action of heat, and the present discussion on the effect of pressure is a new one. In reply to it, however, it may be said, that though, under the circumstances, increase of pressure may be accompanied by increase of head of water, the effect of pressure on the *mineral* or rock would be to close the pores and retard the supposed capillary action, just as a squeezed sponge will not hold so much water as a loose one. On the other hand, it would facilitate a certain kind of chemical change by bringing the molecules more within range, and might thus cause hydration, not mechanically, but chemically; other kinds of chemical change it would retard.

2. Mr. S. S. Buckman complains that statements which are really his are made to appear as mine. I cannot find them. Everything not in square brackets is supposed to originate with the author of the paper. He cannot see that his species are of a "most restricted kind" because he has only made five new species out of 27. True; but the other 22 are already of the most restricted kind. I have not a word to say against, but only admiration for, the *principle* of working out genetic series; but a genetic series is not a zoological genus, but something more restricted; and the reasons relied upon by Mr. Buckman, when given, for considering two forms genetically connected are certainly to me in many cases "apparently arbitrary." Take the case discussed of *Haugia occidentalis*. It is said to be a senile form, and to have lost the knobs characteristic of the *variabilis* group. But the only proof offered that it belongs to the group is the statement (under *H. Eseri*) that this "is very plain from their suture line" which is nowhere either figured or described for *H. occidentalis* that I can find; and though the author subdivides the strata most minutely, this and the knobbed forms occur in the same subdivision. Is not then the assumption that this is a senile form of a knobbed genetic series an arbitrary one?

Next as to *H. Eseri*. Is it possible, indeed probable, that the figures 3, 4, are meant for the true *H. Eseri* of Oppel; but fig. 3 is

drawn with a rounded and not an angular or even perpendicular edge to the umbilicus as it should be. *To judge from the figure*, it would be a different form.

As to *G. Aalense*. If specimens with different-sized umbilicus, different character of ribbing, and different shape of inner edge, are all varieties of one species, and no indication given of what is the common feature that binds them all together, something further in the way of "proof" does seem possible.

G. subquadratum versus *G. Sæmanni*. No two specimens of Ammonite are probably identical, but these *seem to me* (and that is all I say) to be so alike, even in the matter of coiling, after measurement, that no sensible differences can be appreciated from the figures.

On the question of the keel on the cast of a hollow-keeled Ammonite I am clearly in the wrong. I was certainly not aware that so well-marked a one could co-exist with a hollow keel above it, till Mr. Buckman was kind enough to send me a specimen in which the fact is indubitable.

3. Mr. Lydekker says that a superficial knowledge of the subject would enable any one to gauge the value of my criticisms. I do not think myself that it requires even a superficial knowledge to appreciate them, merely some common sense. It certainly never struck me that *Orthopleurosaurus* was meant for a simple rectification of *Orthocosta*, in spite of the somewhat superfluous remark that the latter is hybrid. The proper rectification, following the author's guidance of "*polydens*" changed to "*multidens*," would be *Recticosta*. We are not told whether this is objected to, or whether it and *Orthopleurus* are preoccupied, nor is any reason given why *-saurus* is added on, so that even now no reason is given for the actual result of the change.

4. Dr. Callaway has ordered pistols for two and coffee for one. But he scarcely expects me, I think, to accept his challenge. I have nothing to gain by doing so, if victorious. The fact is, I am so thoroughly convinced of my own power of making a mistake, even when it seems most obvious that I cannot have done so, that I never come to a conclusion of my own, much less propound one for the acceptance of others, till it rests on so many foundations that I feel sure they cannot all be wrong; the advantage of which is that I can afford to give away a few, if contested, without the conclusion being much damaged. I do not by any means give away the observations in question; but if Dr. Callaway likes to take them, it is not worth while to run after him.

NOTICES OF MEMOIRS

I.—Fossil Dragon-Flies.

IN the following work—A Synonymic Catalogue of *Neuroptera odonata* or Dragon-flies, by W. F. Kirby, F.L.S., etc., 8vo. Gurney & Jackson, London, 1890—is an Appendix (pages 165–176) enumerating all the known Fossil *Odonata*, with authorities,

synonyms, geological stages, and localities. This useful catalogue comprises—Libellulidæ.—Libellulinæ: 3 genera, namely, Æschnidium (3 species), Libellulium (3 species), Libellula (20 species). Libellulidæ.—Corduliinæ: 1 genus (2 spp.). Æshnidæ.—Gomphinæ, 10 genera; Æshna (3 spp.), Gomphoides (2 spp.), Ictinus (1 sp.), Protolindenia (1 sp.), Heterophlebia (7 spp.), Stenophlebia (5 spp.), Cordulegaster (3 spp.), Cymatophlebia (1 sp.), Uropetala (4 spp.), Petalura (3 spp.). Æschnidæ.—Æschninæ, 2 genera; Anax (1 sp.), Æschna (11 spp.). Agrionidæ.—Agrioninæ, 3 genera; Isophlebia (2 spp.), Tarsophlebia (1 sp.), Euphæa (3 spp.). Agrionidæ.—Cœnagrioninæ, 7 genera; Podagrion (1 sp.), Dysagrion (3 spp.), Cœnagrion (10 spp.), Steropoides (1 sp.). Lithagrion (2 spp.), Agrionidium (1 sp.), Lestes (5 spp.).

Geologically the species appear to be distributed thus:—

Miocene: Œningen, 15; Schossnitz, 3; Auvergne, 1; The Brown Coal, Rott & Sieblos, 9; Amber, East Prussia, 3.
Oligocene: Radoboj, 3; Florissant, 7.
Eocene: Provence, 1; Monte Bolca, 1; Wyoming, 3.
Cretaceous: Queensland, 1.
Purbeck: 7, Dorset and Wilts.
Jurassic: 31, Solenhofen, Eichstädt, Pappenheim.
Lias, Upper: 3, Dumbleton.
Lias, Lower (and Rhætic): 5, Strensham, Binton, Cheltenham, Schambelen.

T. R. J.

II.—The Geology and Mineral Springs of Pantellaria. By Cav. G. Jervis, F.G.S. "The Mediterranean Naturalist," Malta, December 1st, 1891, Vol. I. No. 7, pp. 93–96.

PANTELLARIA, the largest of the outlying islands belonging to Sicily, and containing one of the twelve Sicilian volcanoes, lies 53 miles from Sicily, and 34 from the coast of Tunis. It is 8½ miles in length and 4½ in breadth, with an area of 25,423 acres. Its Montagna Grande rises 2742 feet, and it has other mountains of less height. The south and east sides have precipitous cliffs; but at the northern extremity the ground slopes gently downwards to the coast with its little port. The town of Pantellaria has 3167 inhabitants; and 4148 people live in the five country villages or groups of cottages. Volcanic rocks, and rich soil from their decomposition, constitute the country. The volcano itself had numerous prehistoric eruptions, from centre and sides. As a member of the Lipari, Vulcano, and Ischia system, it may not be regarded as quite extinct, especially since earthquake shocks, and a submarine eruption not far from the coast, occurred in October last. It may be noted that an upheaval of the sea-bed for 40 fathoms would convert the Adventure Bank, now about 40 miles from Pantellaria towards Marsala, into an island, 14 miles long, and 3 miles broad, and rising nearly 200 feet above sea-level. Thirty-seven miles N.E. of Pantellaria, and 25 miles from the south coast of Sicily, the Graham Shoal remains where the submarine volcano in 1831 formed the

island which has since gradually disappeared. East of Pantellaria, in the direction of Malta, the little island Limosa is also volcanic, thus widening the extent of this volcanic region.

Like Ischia, Pantellaria has thermo-mineral springs, used formerly by the Romans and Arabs; and indeed of the same character as those of Vichy and Ischia; and, if the surroundings were rendered more favourable by the removal of the convict-station to some other Italian island, and if some little capital were then judiciously laid out, these medicinal waters might have much therapeutic and economic importance as a convenient Mediterranean resort. In the eastern part of the island are the Candareddu de lu Bagnu; also the Bagnu or hot lake in an old crater; and the Acqua della Grotta di Gadir. At the S.W. end of the island is the Acqua della Cala Nità, the hottest of all; not far off the Acqua del Porto di Saura Basso; and northwards, about five miles from town, is the Acqua salina di Sataria. There are also fumaroli, or emanations of aqueous vapour. One, termed Bagno secco, is in a cave, forming a Stufa or Sudatorium.

Some sulphur occurs in old fumaroles. The alkaline bicarbonates in the Candareddu de lu Bagnu and the Cala Nità transform the silica of the rock into soluble gelatinous silica, and then deposits it as a dirty-white or grey opal. Obsidian, pozzolana, pumice, and some special minerals also occur in the island. The mineral wealth and springs of Sicily and Pantellaria are described in Mr. Jervis's "Mineral Waters of Southern Italy," and "Subterranean Treasures of Italy."[1] T. R. J.

III.—The Existence of Numerous *Radiolaria* in the Jurassic and the Eocene of the North of France. By L. Cayeux. (Annales de la Société Géologique du Nord, Vol. XIX. 1891, pp. 300–315.)

§ I. M. Cayeux has found *Radiolaria* (1) In some Eocene tuffeaus (tufaceous limestones); (2) In the Oxfordian "gaize" (clay) with *Ammonites Lamberti*. They will be described in detail by-and-bye. 1. The rocks improperly termed "tuffeaux" consist of organic debris with a siliceous cement. The organisms are Sponge spicules, a few Diatomaceæ, and a large number of various spheroidal skeletons of *Radiolaria*, belonging to Häckel's *Monosphæridæ* and *Disphæridæ*. *A*. The Landenian Tuffeau at Bouchevesnes has about a sixth of its bulk made up of *Radiolaria*; at Malincourt Tournay, Lille, Angre, and Radinghem they are rare. *B*. The Ypresian Tuffeau of Mont-des-Cats.

These discoveries in the Lower Eocene are important in as much as the *Radiolaria* described by Shrubsole from the London Clay are the only other Eocene forms known, if those described from the jasper of Tuscany be really Jurassic as regarded by Rüst and Häckel.

2. *Radiolaria* have been found in the Oxfordian Clay at Launois, Lalobbe, and La Neuville (Ardennes). Microscopic sections of small hard morsels of this "gaize" show a somewhat similar structure to

[1] Geological Mag. 1889, pp. 176–177.

that of the "tuffeaux"; but quartz and other minerals are less abundant, Sponge spicules rarer, and Diatoms are absent, whilst *Radiolaria* make up a third or even a half. The minute sphæroidal objects are less globular and smaller; but, when isolated, prove to be *Radiolaria* of Häckel's *Sphæridæ* group, a large number belonging to the *Disphæridæ*. M. Cayeux has not found *Radiolaria* in the Cretaceous "gaizes." Dr. Rüst has discovered quantities in the Jurassic jaspers, flints, cherts, etc., of Hanover, Bavaria, the Tyrol, etc. The Oxfordian clays above mentioned are to be regarded as ranking with Häckel's "mixed Radiolarian rocks"; not being so rich as "the pure Radiolarian rocks" of Nikobar (Oligocene), Barbadoes (Miocene), and the Jura (Jurassic); and therefore deposited at a less depth than 2000 fathoms, to which condition the included quartz sand also has reference.

§ II. The probable origin of the silica in the Gaize and the Tuffeaux. M. Cayeux, previously treating of the microscopic fossils of the tuffeau and gaize, and of the Meule (Millstone) of Bracquegnies, showed that there are Sponges in each of these, that there are Sponges and Radiolarians in the "gaize," and, besides these, numerous Diatoms in the "tuffeau." These organisms naturally secreted silica from the sea-water, and left it when they died. The origin of the flint of the Chalk is here referred to this kind of intervention on the part of Sponges, and the silica of the tuffeaux and gaizes to the above-mentioned siliceous organisms. In these opinions the author finds support in conclusions arrived at by Dr. Hinde and Messrs. Jukes-Browne and Hill. T. R. J.

REVIEWS.

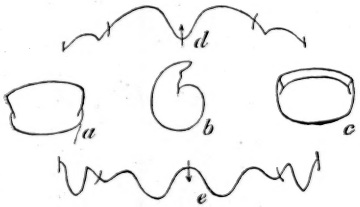
I.—Note on the Discovery of Clymenia in North America.

THE recent discovery of *Clymenia* in the Upper Devonian (*Intumescens*-zone) of Western New York by Mr. John M. Clarke is as unexpected as it is interesting.[1] The *Clymenia* was found in a calcareous concretion in Shurtleff's Gully, Livingston County, New York," not far up in the shales of the Naples Beds," and was accompanied by specimens of *Gephyroceras*, *Tornoceras*,[2] *Bactrites*, sp. nov. (near to *B. carinatus*, Münst.), *Loxonema Noe*, Clarke, *Palæotrochus præcursor*, Clarke, *Platystoma minutissimum*, Clarke, etc. The specimens comprised "about thirty examples of a single species [*Clymenia* (*Cyrtoclymenia*) *Neapolitana*, sp. nov.] in an exceptionally fine condition of preservation, affording the various stages of growth from the protoconch to maturity." The species is remarkably small, the largest mature individual collected having a diameter of only 14 millimetres. The umbilicus is wide, exposing all the volutions, the number of which is $5\frac{1}{2}$ or 6. The whorls are flattened on the

[1] See Amer. Journ. Sci. Jan. 1892, vol. xliii. p. 57.

[2] It may be well to explain that the names *Gephyroceras* and *Tornoceras* apply to genera of *Goniatites*, erected by Hyatt out of the old genus *Goniatites*.

sides and periphery, widening towards the dorsal or inner side. It results from this that the section of the body-chamber is subtrapezoidal. The protoconch (Figs. *a*, *b*, *c*) or initial-chamber, which Mr. Clarke had the good fortune to develop, is "broad, transversely ellipsoidal, and has a diameter of 0·9 millimetres." The flattening of the periphery just described, is not apparent until the 5th and 6th whorls are attained. In these the body-chamber is covered with "fine elevated, falciform striæ," which bend sharply forward on either side of the periphery, upon which they form a backwardly directed curve. The ornamentation of the early whorls is very characteristic, and consists of a series of "lamellar, spinous processes" on the margins of the periphery. The dorsal (internal) position of the siphuncle was observed in several instances.



Clymenia Neapolitana, Clarke.

a—c, Three views of the initial-chamber (protoconch); *d*, the form of the suture at 2¼ revolutions; *e*, the mature suture. (After J. M. Clarke.)

The form of the suture-line will be understood by referring to the figures (*d*, *e*). The author compares his species with *Clymenia spinosa*, *C. binodosa*, and *C. subarmata*, all of Münster. From the last-named species it differs essentially in the mature suture. Its resemblance to *C. spinosa* is shown in its having similar spinous processes on the sides of the whorls in the young shell, while in its suture-line and flattened periphery it is allied to *C. binodosa*.

The restriction of *Clymenia* to the Upper Devonian of Europe is, so far as the present discovery shows, maintained in America, though it occurs at a comparatively lower horizon in that formation in the New World than it does in the Old. "It may be provisionally suggested," observes Mr. Clarke, "that the fauna of the Naples beds embraces representatives of the whole series of the European Upper Devonian faunas from the base of the Goniatite limestone to the base of the Culm; that it is, therefore, a condensed time-equivalent of a series highly differentiated in the transatlantic Upper Devonian succession."

By this important discovery Mr. Clarke has added to his reputation as a palæontological investigator, and geologists no less than palæontologists will rejoice that the invertebrate fossils of America now, as in past time, find such able and enthusiastic exponents.

A. H. F.

II.—Geological and Natural History Survey of Canada. Annual Report (New Series): Vol. IV. 1888–89. (Montreal: William Foster Brown, & Co., 1890.)

THIS voluminous work consists of ten reports, each of which is separately paginated, and distinguished by a letter of the alphabet. Some conception may be formed of the wide extent of country covered by the Survey when we read that in April 1889 sixteen parties were organised for field exploration, and were distributed as follows:—British Columbia, 3; North West Territory, 2; Manitoba, 1; Ontario, 2; Quebec, 4; New Brunswick, 2; Nova Scotia, 2. The Summary Reports by the Director (Dr. A. R. C. Selwyn, C.M.G., F.R.S.) head the list. These contain brief accounts of the Surveys undertaken during the season of 1888–89, with statistics relating to the Museum at Ottawa (the head-quarters), and details of the various additions made to the collections, in the shape of fossils, recent mammals, birds, reptiles, insects, shells, and plants. The first report is by Dr. George M. Dawson, and refers to a portion of the West Kootanie district of British Columbia. This survey was undertaken with "the special purpose of ascertaining the character and mode of occurrence and association of the ore-deposits, and of estimating their prospective importance." The district is described as rugged and mountainous, and as comprising the southern portions of the Selkirk and Columbia or Gold Ranges of Mountains. Its physical features are described in detail, as to its rivers (Kootanie and Columbia), lakes (Upper and Lower Arrow, and Kootanie), climate, vegetation, and, finally, its general geological features. The geological structure is extremely complicated, and the information obtained during the survey (which only occupied one month) is insufficient for a systematic description of the rocks occurring in it. Nevertheless some clues were obtained regarding the origin and habitus of the ore-deposits—chiefly silver-bearing.

"Speaking generally of the district," writes Dr. Dawson, "I may say that the result of my examination has been to convince me that the importance of the mineral discoveries made has not been exaggerated, while their number and the area over which they are distributed is such as to guarantee a large and continuous output of good ore, so soon as adequate means are provided for the transport of the product to market."

The oldest stratified rocks of the district, as seen near the shore of Kootanie Lake, are provisionally referred to the Archæan under the name of the Shushwap Series, and consist of mica-schists and gneisses, with which are associated hornblende-schists, and hornblende-gneisses, as well as coarsely crystalline marbles. Overlying these rocks (at Hot Springs) is a great thickness of grey and green schists, and these in turn are followed by limestones and black argillaceous schists, a mass of granite bounding the whole at a distance of two to three miles inland. "In evident relation to this change in the country-rock is the circumstance that the ores improve almost uniformly in respect to contents of silver in crossing the series of veins in a westward direction from the lake, and rising

higher above the lake level." It is believed that the rocks overlying the Shushwap Series are in all probability Palæozoic in age, and may eventually be referred to various systems, including the Carboniferous, and extending downward to the Lower Cambrian.

Dr. Dawson's report is accompanied by a "reconnaissance" map (coloured geologically) on a scale of four miles to the inch, and is also illustrated by two views of Kootanie Lake.

Mr. R. G. McConnell, assistant to Dr. Dawson, gives the results in Report D. (pp. 1 D to 163 D) of an exploration in the Yukon and Mackenzie Basins, North West Territory. The Survey was carried out under Dr. Dawson's direction, and in connection with the Yukon Exploring Expedition. It occupied parts of the seasons of 1887-1888. In a "Geological Summary" the occurrence of Archæan rocks is noted east of the Rocky Mountains, on the Slave River, and at Fort Rae, while unfossiliferous dolomites, limestone, and calc-schists, supposed to be of Cambro-Silurian, or later Cambrian age, were met with along the Liard River, west of the Rocky Mountains. Upper Devonian rocks containing many characteristic fossils were observed on the Hay and Mackenzie Rivers, and Triassic rocks and fossils on the Liard River. Cretaceous rocks were recognized east of the foot-hills, containing fossils similar to "Series C." of the Queen Charlotte Islands; among them were *Placenticeras Perezianum*, *Camptonectes*, and *Inoceramus*. Tertiary beds, resting unconformably on the underlying Cretaceous shales and Devonian limestones, were seen at the mouth of Bear River. Remains of plants, described or determined by Sir William Dawson, were abundant in some of the beds. The age of these Tertiary beds is judged, on stratigraphical, as well as lithological evidence, to be Miocene, though Sir William Dawson refers them, on the plant evidence, to the Laramie. A chapter on "Superficial Deposits and Glacial Action," and a synopsis of the economic minerals of the region, which include Gold, Silver, Copper, Salt, Petroleum, etc., concludes the geological portion of this report; the remainder is taken up with a minute description of the physical features of the routes followed by the surveying party. The report succeeding Mr. McConnell's in the series is on the Exploration of the Glacial Lake Agassiz in Manitoba, by Mr. Warren Upham (pp. 1 E. to 156 E.); but it has already been reviewed in its separate issue in this MAGAZINE (May, 1891, p. 228). Dr. R. W. Ells presents a report (pp. 1 K. to 159 K.) on the Mineral Resources of the Province of Quebec, in which he describes the metals and their ores (Gold, Silver, Copper) and the various minerals used for heating and lighting (Coal, Peat, Petroleum); chemical manufactures (Apatite, Chromic Iron, Manganese), materials used in construction (Marbles, etc.), and the refractory materials, which include Graphite, Asbestos, and Soapstone. Mr. Robert Chalmers reports upon the Surface Geology of Southern New Brunswick (pp. 1 N. to 92 N.), and records the results of careful investigations, in the cleared and settled parts of the country, in regard to glacial striæ, Boulder-clay, stratified deposits, alluvium, the agricultural character of the soil, forests, etc.

The author failed to find any traces of a continental glacier, though he examined the glaciation of the eastern extension of the high pre-Cambrian ridge or plateau bordering the Bay of Fundy with some care. On the contrary, great masses of decayed rock *in situ* encumber the northern and north-western flanks of the ridge, while along the valleys of rivers descending from it northwardly striæ were found clearly indicating northerly ice movements. Till or Boulder-clay was found wherever there were traces of glacier or iceberg action, and in some places where there were none. Mr. G. Christian Hoffmann (pp. 1 R. to 68 R.) reports upon the work carried on in the Laboratory of the Survey, in which he was assisted by Mr. Frank D. Adams,[1] and Mr. R. A. A. Johnston. A report upon the Mining and Mineral Statistics of Canada for the year 1888 is supplied by Mr. H. P. Brumell (pp. 1 S. to 93 S.); and Mr. E. D. Ingall, Mining Engineer to the Survey, presents his "Annual Report" for 1889 upon the same subject (pp. 1 S. to 123 S.). An "Annotated List of the Minerals occurring in Canada" by Mr. Hoffmann (pp. 1 T. to 67 T.), closes this bulky volume, of which the foregoing brief notice can give but a very inadequate idea. We can only express the hope that the work of the Geological Survey of Canada is duly appreciated by those for whose benefit it is undertaken, and that successive Administrations will maintain it in the high state of efficiency it now enjoys. A. H. F.

III.—Tenth Annual Report of the United States Geological Survey, 1888–89. By J. W. Powell, Director. Part I.—Geology. 1890, pp. 774, plates and maps, xcviii.

THE present Report, like those which have preceded it, bears the stamp of the high degree of excellence which the Survey has attained under the direction of Major J. W. Powell, with the assistance of a staff which seems to include nearly all the principal geologists of the United States. The field of investigation comprises the whole of the country; it takes in every formation, from the Pleistocene to the Archæan, and embraces every branch of the science, whether Stratigraphical, Petrographical or Palæontological. To give a list only of the different branches of the work, which, as shown in the Director's Report and in that of the Administrative Chiefs, is being carried out in different parts of the country, would more than occupy our space, and we can here only touch on some points of special interest. One of these is the discovery by Dr. C. A. White in certain counties in Texas of a group of rocks, containing an admixture of Palæozoic and Mesozoic types of fossils belonging to one fauna, which show a conformable passage of the Coal-measures into the Mesozoic series, and thus fills up one of the widest breaks in the geological succession in the United States, viz., that between the Carboniferous and the Jura-Trias. Another series of rocks with similar fossils has also been noticed in Southern Kansas.

[1] Mr. Adams has since been appointed Lecturer on Geology at McGill University, Montreal.

In Archæan geology, Prof. Pumpelly has studied the structure of the Green Mountain Range, which consists of a series of closely appressed and overturned folds with a pre-Cambrian crystalline core, and a surface of rocks apparently representing the Silurian, from the Hudson River downwards, and the whole of the Cambrian, as shown in Eastern New York.

Dr. G. H. Williams has been at work on the crystalline rocks of the Piedmont Region, in the Middle Atlantic Slope, and the volcanic and other crystalline rocks about Baltimore. He has made out in the volcanic rocks a sequence of basic, ultra-basic, and acidic eruptions, following each other in accordance with von Richthofen's law.

At the other end of the scale, Prof. N. S. Shaler has been mapping the morasses and superficial deposits of Massachusetts, Rhode Island, and New Hampshire, and he estimates that nearly one-half of the swamp areas in the United States, which by suitable treatment may be made fit for agriculture, are to be attributed to the disturbance of the drainage by the last Glacial Period.

One distinctive feature of this report is the establishment of a division of geological correlation, under the superintendence of Mr. G. K. Gilbert. The specialists in each geological group or system have to prepare essays on the present state of knowledge of North American systems; on the principles of geological correlation and taxonomy; and on the possibility or otherwise of using in all countries the same set of names for stratigraphical divisions smaller than systems, from the American standpoint. Further, as the result of a conference of the members of the Survey, an independent system of nomenclature, of colours and conventional symbols for maps, has been adopted.

Of the papers or monographs accompanying this report, the principal is that of Mr. C. D. Walcott on the Fauna of the Lower Cambrian or Olenellus zone, which has already been reviewed in this Magazine. Another is that on the Morasses, etc., by Mr. N. S. Shaler, and a third is an abstract of a report by the late Prof. R. D. Irving and Prof. Van Hise on the Penokee iron-bearing series of Michigan and Wisconsin. This series of rocks situated on the south and west shores of Lake Superior, has a thickness of about 14,000 feet. It is placed by the authors as a distinct system, named the Algonkian (=Huronian), coming between the Cambrian and Archæan. The lowest member of the iron-bearing series in this region is a cherty limestone in which bands of white chert or quartz are interlaminated with the limestone. The cherty material in some places is 45 feet in thickness, and the silica varies from amorphous to crystalline. One peculiar feature in this chert is the tendency to assume a brecciated form, in which angular fragments up to 2 or 3 inches across are imbedded in chert of a precisely similar character. Sometimes the brecciated portions are wholly included in the cherty zone. Though no organic remains have been met with, either in the limestone or the chert, the authors consider that both kinds of rock are probably of organic origin, and they compare the chert with the beds of the same material which in this and other countries have lately been proved to be derived from organisms.

Above the limestone and chert series is a set of rocks known as quartz slates of a distinctly fragmental texture. The iron-bearing member is next above and consists of slaty and often cherty iron carbonate, ferruginous slates and cherts, and actinolitic and magnetitic slates. The iron-carbonate is sometimes mingled with cherty silica, sometimes the two materials are in solid bands, alternating with each other. In some of the carbonates of the Penokee series there still remains a large percentage of organic matter. The authors further show that the deposits of iron-ore now largely worked are in part due to a concentration of the carbonate of iron which had been widely distributed in the higher strata. They consider that the chert was simultaneously deposited with the iron-carbonate, and that there has probably been an extensive re-arrangement of the silica originally present.

IV.—Bulletin of the United States Geological Survey. Nos. 62, 65, 67 to 81. 8vo. Washington, 1890–91.

THE latest numbers of this publication which have reached us show that the United States Survey, under the able direction of the Hon. J. W. Powell, still maintains its high standard of excellence, and is as much a pattern to our authorities as ever, save in the delay that takes place in their issue. The wide extent of ground covered by these mostly bulky numbers is certainly remarkable. Nothing comes amiss, provided it bears in any way on the work of the Survey. Thus we have a report on the astronomical work of 1889 and 1890 (No. 70). Two numbers (72 and 76) are lists of altitudes; the latter being a second edition of the "Dictionary of Altitudes in the United States," and not a bad gazetteer at a pinch. The "Viscosity of Solids" (73), and the "Report of work done in the division of Chemistry and Physics" (78), together with "Earthquakes in California in 1889, by J. E. Keeler" (68), which is a continuation of the lists given by Prof. E. S. Holden up to 1888 in a previous number, bring the list of Bulletins that are not strictly geological to an end.

Turning next to the stratigraphical memoirs we light first on G. H. Williams (62), "The greenstone schist areas of the Menominee and Marquette Regions of Michigan," which is "a contribution to the subject of Dynamic Metamorphism in Eruptive Rocks;" the greenstones, and certain intimately associated acid rocks, are alone dealt with, no attention being paid to the quartzite, dolomites, or shales of the younger Huronian. The conclusion arrived at is that the greenstones of these areas are eruptive rocks, the foliated character of which is a secondary feature.

"The relations of the Traps of the Newark System in the New Jersey region" form the subject of No. 67. Mr. N. H. Darton shows that in their genetic relations these traps belong to two classes; first the extrusive sheets contemporaneous with the inclosing strata, and typified by the great lava flows constituting the Watchung Mountains; and, second, intrusive sheets and dikes of subsequent age, of which the celebrated Palisade trap on the shore of the Hudson River is an example.

Mr. J. S. Diller describes "A late Volcanic eruption in Northern California" (79). The cinder cone, 10 m. N.E. of Lassen Peak, marks the scene of one of the very latest volcanic eruptions in the United States, and is composed wholly of ejecta inclosing a perfect crater 240 feet deep. Two epochs of eruption are noted as having taken place, the first about 100 years before the American revolution, the second at a much later date, but more than 50 years ago. The lava, which is a basalt, is especially noteworthy on account of the phenocrystic quartz which it contains.

The "Stratigraphy of the Bituminous Coal-field of Pennsylvania, Ohio, and West Virginia" (65), is dealt with by Mr. J. C. White in a very exhaustive manner, and illustrated by no less than 152 woodcuts of sections in 212 pp. of text. "Correlation Papers" form the subject of two Nos. (80 and 81), "Devonian and Carboniferous by H. S. Williams," and "Cambrian by C. D. Walcott." Both these are bulky papers, and as they summarize the results obtained by all previous observers. their extreme value to all students of Palæozoic geology cannot be overrated.

In Bulletin No. 77 is presented a summary of the evidence that may be accepted as indicating the Permian age of a certain series of strata in Western Texas, which have been referred sometimes to the Trias and sometimes to the Permian. The discovery in these beds is moreover recorded of certain types of invertebrate fossils which are usually regarded as indicative of Mesozoic age, commingled with a considerable number of Carboniferous types, including well-known Coal-measure species.

Two important compilations relating to fossil Insects come from the pen of Mr. H. S. Scudder:—No. 69 "A classed and annotated Bibliography of fossil Insects" pp. 101, and No. 71 "Index to the known fossil Insects of the world, including Myriapods and Arachnids," pp. 744. What, we wonder, would the authorities of H. M. Stationery Office say were our Survey to suggest the publication of a series of useful bibliographies such as these? The first is an extension to date of the one published in 1882 by the Harvard University as No. 13 of their "Bibliographical Contributions," when it only covered half the number of pages it now takes up. Some of the increased space is of course due to the repetition of titles entailed by the adoption of the classified form in the later edition; but still more to the careful manner in which references bearing in any way on the subject have been looked up and included.

The "Bibliography" is supplemented by the "Index," which is a work no palæontologist, even if it be not his special subject, can well afford to be without; and is exactly what its title describes. The only improvement which suggests itself is that it would have been well to add when possible where the type specimen is now to be seen.

"The Minerals of North Carolina by F. A. Genth" (74) is essentially a new edition of the report published by the Geological Survey of North Carolina in 1881. In the present memoir many new analyses will be found; whilst the "Synopsis of Minerals and Mineral Localities, by Counties," with which the work terminates, will be of especial value to the field geologist and the collector of minerals.

In Bulletin No. 75 Mr. N. H. Darton gives a "Record of North American Geology from 1887 to 1889 inclusive." He has previously published one for 1886, which appeared in the same series in 1887. For terseness and the clear way in which the contents are set out, so that the eye of the searcher is not wearied in its endeavours to find the particular paper wanted, we recommend this production to the attention of any who may be disposed to attempt the revival of the ill-starred and more ambitious "British" prototype now years behind time.

V.—The South Italian Volcanoes. F. Furcheim. Naples.

THIS work is one of the results of the excursion of the Geologists' Association to Southern Italy in 1889. The account of the excursion is written by Dr. Johnston-Lavis, who acted as principal director. On September 18th the party embarked at Messina, on a small steamer which had been chartered for a week's cruise amongst the Lipari Islands. In the portion of the report dealing with this part of the excursion much interesting geological information is given, and the exact state of the active vents of Vulcano and Stromboli is described. On returning to Sicily the party proceeded to examine the phenomena of Etna, under the able guidance of Prof. O. Silvestri, of Catania. The celebrated Val di Bove was visited from Acireale, and the central crater from Catania.

On October 1st the party assembled at Naples, and the second part of the excursion was commenced. A fortnight was most profitably spent in this classic region, and the usual objects of interest were visited. The great extinct crater of Roccamonfina was examined on the way to Rome, where the excursion was brought to a successful termination on Oct 28th. Visitors desirous of studying the volcanic phenomena of Southern Italy will find, in this report, valuable information as to the best way of employing their time.

The account of the excursion forms only a small portion of the volume. Of the 335 pages, 239 are devoted to an exhaustive bibliography of the district, which has been compiled by Madame and Dr. Lavis. There are also papers on special subjects by Messrs. Platania, Lavis, Sambon, and Zesi. Sixteen plates complete the volume. Fifteen of these are excellent reproductions of photographs, and three which illustrate successive stages of an explosion in the crater of Vulcano are extremely interesting. They convey a vivid impression of the actual nature of the phenomenon.

The Geologists' Association and Dr. Lavis are to be congratulated on having so successfully carried out a somewhat ambitious programme. They were received with great cordiality by many Italian geologists, and on several occasions experienced great kindness and hospitality at the hands of local authorities.

Now that the slight inconveniences necessarily attendant on such an excursion are forgotten, the members who took part in it must look back with unalloyed pleasure to the time so profitably spent in a district full of interest, both from a geological and from a historical point of view.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Annual General Meeting.—February 19th, 1892.—Sir Archibald Geikie, D.Sc., LL.D., F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1891. In the former the Council again congratulated the Fellows on the continued prosperity of the Society, and the perfectly satisfactory condition of its finances.

The number of Fellows elected during the year was 63; of these 43 qualified before the end of 1891, together with 19 previously elected Fellows, thus making a total accession of 62 Fellows during the year 1891. As, however, from this number a deduction of 50 must be made for losses by death, resignation, and removal, and for new Fellows compounding, the actual increase in the number of Contributing Fellows amounts to 12. The total number of Fellows, Foreign Members, and Foreign Correspondents at the close of 1891 was 1418.

The Balance-sheet for the year 1891 showed receipts to the amount of £2845 9*s.* 8*d.*, and an expenditure of £2476 5*s.* 7*d.* Moreover, the sum of £516 2*s.* 3*d.* was expended in the purchase of stock, and the balance in favour of the Society at December 31st, 1891, amounted to £286 19*s.* 4*d.*

The Council's Report also referred to the severe losses sustained by the Society during the year in the deaths of several distinguished Fellows, to the death of the late House-Steward, to the editing of No. 185 of the Quarterly Journal by Prof. T. Rupert Jones, and in conclusion announced the awards of the various Medals and proceeds of Donation-Funds in the gift of the Society.

The Report of the Library and Museum Committee enumerated the additions made during the past year to the Society's Library, announced the completion of about 40 previously imperfect sets of serials, and referred to the registration of type specimens in the Museum, a task which has been confided to a specialist, Mr. C. Davies Sherborn.

In handing the Wollaston Medal, awarded to Baron Ferdinand von Richthofen, to Mr. W. Topley, F.R.S., for transmission to the recipient, the President addressed him as follows:—

Mr. Topley,—To Baron Ferdinand von Richthofen the Council of the Geological Society has awarded this year the Wollaston Medal in recognition of the great merit of the researches carried on by him over a large part of the Old World and of the New. From the outset of his career he has been distinguished by a rare combination of the power of minute patient observation, with the faculty of broad, and often brilliant, generalization. It is this union of mental gifts which has placed him high among the leaders of science of his time, and which gives such a charm and value to his writings.

Beginning his early investigations among the eruptive rocks of his native country, he was gradually led to undertake a detailed investigation of the geology of that interesting region in the South Tyrol around Predazzo and St. Cassian. The elaborate monograph of this tract, which he published in 1860, was a remarkable achievement for so young a man, and gave ample promise of his future distinction. Soon after its publication he had the good fortune to be attached to a naval

expedition sent out to the East by the Prussian Government to arrange commercial treaties with China, Japan, and Siam. He was thus afforded opportunities of turning to account his power of rapid observation, of enlarging his geological experience, and of meditating upon those problems to the solution of which he might devote his life. We are all familiar with the brilliant series of papers and works which has followed from the labours of the twelve years spent by him abroad.

Crossing the Pacific he came in contact with Professor J. D. Whitney, who was then conducting the Geological Survey of California. The young and eager German was induced to settle for a time on the Pacific border of the American Continent, where he devoted himself to the study of the marvellous volcanic phenomena of that region. Among the contributions made by him to the geology of the United States, his remarkable generalizations as to the order of succession of the volcanic rocks, and the nature of 'massive eruptions' have attracted special attention.

What he had seen of China had convinced him that an investigation of its geology would prove of the utmost interest and value. Accordingly, in the summer of 1868, instead of turning homewards, he returned to that country, and spent somewhere about three years in a series of journeys through the vast Celestial Empire. The massive volumes and splendid atlas which contain his account of China form one of the most important contributions ever made to geological literature. In every chapter there is some luminous remark or suggestive inference that lights up the formidable array of facts with which the pages are crowded. The description of the Chinese Loess and the manner in which the author works out his explanation of that puzzling formation are a model of geological description.

As a geologist, a scientific traveller, an exponent of facts, and a generalizer from facts to their connecting cause, Baron von Richthofen stands in the forefront of the science of our day, and in awarding him the Wollaston Medal this Society does itself as much honour as it seeks to confer on him. When you, Mr. Topley, transmit this Medal to him and express to him our appreciation of his labours, will you also convey to him our personal regard and our hope that he may long be able to continue the work which has rendered his name so illustrious.

Mr. Topley, in reply, said:—Mr. President,—I am desired by Baron von Richthofen to express his extreme regret that important duties detain him in Berlin, and render it impossible for him to be present here to day.

He requests me to offer to this Society his warmest thanks for the honour now conferred upon him, and for placing his name in the list of distinguished geologists to whom this Medal has been awarded.

In a letter which I have just received Baron von Richthofen says:—"If I were personally present I would not fail to remark that I am deeply impressed by the consciousness how unfavourably the humble work I have been able to accomplish compares with the honour now conferred upon it; and that it will be my endeavour to render myself more worthy of it by never ceasing to work in the interests of geological and, what is so nearly related to it, geographical science, my line of research being indeed chiefly in that field where both these branches of science meet.

"British geologists have had the largest share in the geological exploration of other continents than Europe. It has been my lot, too, to do a chief part of my work abroad. This common interest has, among others, contributed to connect me with many of my fellow-workers in science in your country. It is a sincere gratification to me to have this tie strengthened by being put under the obligation of gratitude towards this illustrious Society in which the names of British geologists are embodied."

The feeling of gratification with which Baron von Richthofen will receive this Medal, will, I am sure, be shared by the geologists in Germany and Austria. No one is held in higher honour by them, both for personal worth and scientific attainments, than Baron von Richthofen, and to no one would they more gladly see this Medal awarded.

The President then presented the Murchison Medal to Prof. A. H. Green, M.A., F.R.S., addressing him as follows:—

Professor Green,—In awarding to you the Murchison Medal, the Council desires to mark its sense of the importance of the contributions which you have made to our knowledge of English geology, more particularly in the Coalfield of Yorkshire, with which your name will ever be honourably associated. It might not be appropriate were I to allow myself to dwell on the special value of your geological

labours. I will only say that they long ago placed you among the ablest field-geologists of this country. But besides the work done by you in the field, and expressed on maps and sections, we owe a further debt to you for the clear, terse, and interesting descriptions which you have given of your researches. It is always pleasant as well as instructive to read one of your writings, and this eminent faculty of exposition you have turned to valuable account in your admirable "Manual of Geology." There is to myself a peculiar pleasure in being the channel through which this Award of the Council comes to you, for I can look on an unbroken friendship with you extending over some thirty years. In handing to you the Medal founded by Murchison, I am reminded of your early intercourse in the Geological Survey under that great leader, when we discussed together the questions to which we have each since devoted ourselves. And I am sure I fulfil the desire of every Fellow of this Society when I express the hope that, in your high position at Oxford and in the original research which you will doubtless still carry on, you may continue for many years that career of distinction which we gladly recognize to-day.

Prof. Green, in reply, said:—Mr. President,—Under any circumstances it would be most gratifying to receive from the Geological Society a recognition of my attempts to enlarge the boundaries of our favourite science. But I hold myself specially fortunate on this occasion on two grounds. A Medal that bears the name of the great chief under whom we both served is specially welcome; and a further charm is added when I feel that I am receiving this award from one to whom I have been bound in close friendship for a period of more than thirty years. If anything could strengthen the link that binds us together, it would be the receipt of the Murchison Medal at your hands. I thank most cordially the Society and yourself for the honour you have done me.

In presenting the Lyell Medal to Mr. G. H. Morton, F.G.S., the President addressed him as follows:—

Mr. Morton,—The Lyell Medal has been adjudged by the Council to you in recognition of your long and meritorious services to geology in the work which you have done around Liverpool. To you we are largely indebted for the extent of our knowledge of the Triassic and other strata of that district. Your full and accurate account of the glacial phenomena of your neighbourhood forms an especially important part of your labours. In handing you this Medal, with the sincere good wishes of the Council and of the Society, I may add that, had he been alive, no one would have taken a keener interest in your work or rejoiced more heartily at its due recognition than the illustrious founder of this Medal, Charles Lyell.

Mr. Morton, in reply, said:—Mr. President,—I fear that I shall fail, by any words at my command, to adequately express how much I appreciate the great honour conferred on me by the Award of the Lyell Medal. This kind recognition by the Council of any original work that I may have done is most gratifying, for it is the greatest honour that can be bestowed on a geologist.

The Medal has been awarded to me before I am too advanced in years to hope to do more work, and it will stimulate me to renewed exertion. The pleasure I now feel is increased at receiving the Medal from your hand, Sir, not only as President of the Geological Society, but as the Director-General of the Geological Survey. I thank you for the complimentary manner in which you have referred to my work in the Triassic and other strata around Liverpool.

The President then handed the Balance of the proceeds of the Wollaston Fund, awarded to Mr. Orville A. Derby, F.G.S., to Mr. H. Bauerman, F.G.S., for transmission to the recipient, addressing him as follows:—

Mr. Bauerman,—I have the pleasure of handing to you the Balance of the proceeds of the Wollaston Fund for transmission to Mr. O. A. Derby, to whom the Council has adjudged this Award in recognition of the value of his various communications on the Geology and Palæontology of Brazil. Some of these writings have far more than a local interest. I would especially refer to those in which Mr. Derby gives the results of his petrographical researches on the nepheline-bearing rocks, on the distribution of the sources of the rarer minerals, and on the ore-deposits of the Jacapiranga district. In transmitting this Award to him, will you convey the best wishes of the Council and the Society for his continued success in scientific investigation.

Mr. Bauerman, in reply, said:—Mr. President,—I have been asked, by telegram from Mr. Derby, to represent him, as the interval since the Award was announced has not been sufficient to allow of an acknowledgment by letter. I thank you heartily for the recognition of the excellent work done by Mr. Derby in a country whose geological structure is almost unknown, and I consider that in addition to the honour conferred on the recipient the Award is of value as likely to encourage the local government in carrying on the systematic investigation of the province in the manner that they have so worthily begun.

In presenting the Balance of the proceeds of the Murchison Geological Fund to Mr. Beeby Thompson, F.G.S., the President addressed him as follows:—

Mr. Beeby Thompson,—The Balance of the proceeds of the Murchison Fund has been adjudged by the Council to you as a mark of its high appreciation of the insight, endurance, and enthusiasm with which you have prosecuted your laborious investigation of the Upper and Middle Lias of Northamptonshire. Your minute tracing of the successive zones of these formations admirably shows how the Maps of the Geological Survey may be made to serve as the basis for more detailed and exhaustive work, such as can only be undertaken by a permanent resident in a district. We hope that this Award may encourage you to persevere by showing how cordially you possess the sympathies of this Society.

Mr. Beeby Thompson, in reply, said:—Mr. President,—I feel greatly the honour that has been conferred upon me by the present Award. I am a comparatively young geologist, and commenced the study of the science some twelve years ago in connexion with the Northamptonshire Natural History Society. My highest ambition at first was to give a connected *résumé* of all that had been published on the local geology; but I soon found deficiencies in the record, and these I have since done my best to supply. It is now one of the greatest pleasures of my life to go out into the field and interrogate the rocks; and although we frequently come to violent blows, I hope we shall ever remain the best of friends.

I thank you, Sir, for the kind and encouraging words with which you have accompanied this presentation.

The President then presented one-half of the Balance of the proceeds of the Lyell Geological Fund to Mr. J. W. Gregory, B.Sc., F.G.S., addressing him as follows:—

Mr. Gregory,—One moiety of the Balance of the proceeds of the Lyell Fund has been assigned by the Council to you as a token of its warm appreciation of your researches and as an encouragement to you to continue them. You have shown yourself to be an accomplished palæontologist and an able petrographer; and we trust that in both capacities you may live amply to fulfil the promise which you have given of a brilliant career in the future.

Mr. Gregory, in reply, said:—Mr. President,—The Fund which the Council has so kindly awarded me helps me to realize more than usual the responsibility of holding an appointment at the Natural History Museum, for I feel that it to the opportunities afforded by its collections and libraries, and by the generous assistance and encouragement of the more experienced members of the staff, that the little that I have been able to do is entirely owing. You, Sir, have kindly referred to the fact that I have occasionally wandered from the work of descriptive palæontology; I can only offer as an excuse for thus presuming to intrude into the other branch of geological work, the desire occasionally to exchange the air of the museum for that of the field, as well as the wish for the training acquired in pursuing the more precise method of research.

This Award will encourage me to try to continue in the path of its founder in regarding fossils not merely as the cells of a phylogenetic tree, but as the witnesses from whose evidence we must learn the physical conditions and faunistic migrations of the successive periods of the past.

In presenting the other half of the Balance of the proceeds of the Lyell Geological Fund to Mr. Edwin A. Walford, F.G.S., the President addressed him as follows:—

Mr. Walford,—The Council has awarded you the other moiety of the Lyell Fund in recognition of the great merit of your studies among the Lias and Lower Oolites and your contributions to our knowledge of the *Trigoniæ* and *Polyzoa* of the Jurassic rocks. We hope that you will accept this Award as an aid and stimulant to further research, and that we may have the pleasure and profit of continuing to receive the results of your labours.

Mr. Walford, in reply, said:—Mr. President,—I thank you for this recognition of such work as I have done. My stratigraphical labours have consisted principally in filling in the details of the broad outlines so well laid down by the officers of the Geological Survey. In palæontology my work among the Mollusca and Bryozoa has been done in the few intervals of leisure snatched from a busy business life. I wish that I had been able to accomplish more, for what I have done is but evidence of what I would wish to do.

The President then handed the proceeds of the Barlow-Jameson Fund, awarded to Prof. C. Mayer-Eymar of Zürich, to Dr. W. T. Blanford, F.R.S., addressing him as follows:—

Mr. Blanford,—In asking you to be so good as to transmit to Prof. Mayer-Eymar a donation from the Barlow-Jameson Fund, awarded to him by the Council, I hope that you will convey to him an expression of the interest we take in the work he is now carrying on so vigorously in Egypt, and of our desire to aid him in it. His previous training in the palæontology of the Cretaceous and Tertiary rocks of Switzerland, France, and Italy eminently qualified him for the task to which he is now devoting himself, and in which we sincerely wish him success.

Dr. Blanford, in reply, said:—Mr. President,—I am very pleased to undertake the duty of transmitting the Award from the Barlow-Jameson Fund to Professor Charles Mayer-Eymar. The money will be devoted to one of the most important objects for which these funds were originally founded—the payment of the travelling expenses of a geologist who is engaged in investigating the structure of a distant country.

Professor Mayer-Eymar, in a letter from Cairo written on the 4th of the present month, asks me to convey his thanks to the Society, expresses his warm acknowledgment of the assistance to his work that the present Award will give, and promises, as evidence of his gratitude, to send in the course of next month, for the information of the Society, an account of his three principal stratigraphical discoveries in Egypt.

The President then said:—Before passing from the subject of the Awards, I should like to refer very briefly to the remarkable and interesting coincidence that this Anniversary day of our Society is also the centenary of one of the great geologists who founded our Medals and Funds. Exactly one hundred years ago (viz. on February 19th, 1792) Roderick Impey Murchison was born. Twenty years have passed away since he was removed from our midst; and at this distance of time we can better estimate the value of his work and its influence on the progress of our science. I do not purpose, on the present occasion, to attempt such a critical estimate. I am sure, however, that I express not my own feeling only, but that of every Fellow of the Society, when I say that though we have been able to correct some of his observations, and discard some of his deductions, the solid work which he accomplished, more especially in the establishment of his Silurian system, stands on a basis which seems even stronger and broader now than when he laid it more than half a century ago. His name has become a household word in Geology, and will go down to future ages as that of one of the great pioneers of the science.

To those who knew him personally and learnt to appreciate the frank, generous, and sympathetic nature that underlay the somewhat formal bearing of the old soldier, this day brings many pleasing memories. That the recollection of his personal worth remains yet fresh without as well as within the pale of our Society has been vividly brought to my knowledge by an incident as unwonted as it is gratifying. Within these few days an old friend of Murchison, who desires to remain unknown, has come to me with the wish to be allowed to offer here a tribute to his memory at this Anniversary of the Geological Society and centenary of his birth. As a mark of sincere admiration for the man as well as the geologist, and with the view of helping to encourage the cultivation of the spirit in which he laboured, I have been asked to select two geologists, by preference Scotsmen, who are disciples of Murchison, or who are carrying on the kind of research to which he devoted himself. To each

of these workers the generous donor asks to be allowed to give a framed portrait of Murchison together with a sum of £50. The conditions of the gift circumscribed my choice, but I feel confident that I shall carry the Society with me when I say that there are pre-eminently two Scottish geologists who have worthily followed in Murchison's footsteps, but with no slavish regard for the opinions of their master, who are continuing and extending his work, and who by their constant association alike in the field and in descriptive writing deserve to share in this tribute to the memory of their former chief. I need hardly say that I allude to Mr. B. N. Peach and Mr. John Horne.

The President then presented an envelope containing a cheque for £50 to Mr. B. N. Peach, and requested him to convey a similar packet to Mr. J. Horne.

Mr. Peach, in reply, said:—Mr. President,—On behalf of my colleague, Mr. Horne, and myself I beg to thank you for your kindness in considering that we have carried on the work of our old chief, Sir Roderick Murchison, in the true spirit, and I beg to request that you will convey our thanks to the unknown donor of this munificent gift.

The President then proceeded to read his Anniversary Address, in which he first gave Obituary Notices of several Fellows, Foreign Members, and Foreign Correspondents deceased since the last Annual Meeting, including Sir Andrew Ramsay (President in 1862–63), Prof. P. Martin Duncan (President in 1876–77), the Duke of Devonshire (elected in 1829), Mr. R. B. Grantham (elected in 1833), Prof. J. Leidy (elected Foreign Member in 1866), Prof. Ferdinand von Roemer (elected Foreign Member in 1859), Baron Achille de Zigno (elected Foreign Correspondent in 1886), the Earl of Northesk, Mr. Frederic Drew, Mr. J. Thornhill Harrison, Sir J. Hawkshaw, Mr. Thos. Roberts, Mr. C. S. Wilkinson, Mr. Kinsey Dover, and Mr. Collett Homersham.

The other portion of the Address was devoted to a continuation of the subject treated of last year, and dealt with the history of volcanic action in this country from the close of the Silurian period up to Older Tertiary time. The remarkable volcanic outbursts that took place in the great lakes of the Lower Old Red Sandstone were first described. From different vents over Central Scotland, piles of lava and tuff, much thicker than the height of Vesuvius, were accumulated, and their remains now form the most conspicuous hill-ranges of that district. It was shown how the subterranean activity gradually lessened and died out, with only a slight revival in the far north during the time of the Upper Old Red Sandstone, and how it broke out again with great vigour at the beginning of the Carboniferous period. Sir Archibald pointed out that the Carboniferous volcanoes belong to two distinct types and two separate epochs of eruption. The earlier series produced vast submarine lava-sheets, the remains of which now rise as broad terraced plateaux over parts of the Lowlands of Scotland. The later series manifested itself chiefly in the formation of numerous cones of ashes which were dotted over the lagoons and shallow seas. After a long quiescence, volcanic action once more reappeared in the Permian period, and numerous small vents were opened in Fife and Ayrshire and far to the South in Devonshire. With these eruptions the long record of Palæozoic volcanic activity closed. No trace has yet been

discovered of any volcanic rocks intercalated among the Secondary formations of this country, so that the whole of the vast interval of the Mesozoic period was a prolonged time of quiescence. At last, when the soft clays and sands of the Lower Tertiary deposits of the South-east of England began to be laid down, a stupendous series of fissures was opened across the greater part of Scotland, the North of England, and the North of Ireland. Into these fissures lava rose, forming a notable system of parallel dykes. Along the great hollow from Antrim northwards, between the Outer Hebrides and the mainland of Scotland, the lava flowed out at the surface and formed the well-known basaltic plateaux of that region.

The address concluded with a summary of the more important facts in British volcanic history bearing on the investigation of the nature of volcanic action. Among these the President laid special stress on the evidence for volcanic periods, during each of which there was a gradual change of the internal magma from a basic to an acid condition, and he pointed out how this cycle had been repeated again and again even within the same limited area of eruption. In conclusion, he dwelt on the segregation of minerals in large eruptive masses and indicated the importance of this fact in the investigation, not only the constitution and changes of the volcanic magma, but also of the ancient gneisses where what appear to be original structures have not yet been effaced.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*Council*: Prof. J. F. Blake, M.A.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; James W. Davis, Esq., F.L.S., F.S.A.; R. Etheridge, Esq., F.R.S.; L. Fletcher, Esq., M.A., F.R.S.; Prof. C. Le Neve Foster, D.Sc., B.A.; Sir A. Geikie, D.Sc., LL.D., F.R.S.; Alfred Harker, Esq., M.A.; H. Hicks, Esq., M.D., F.R.S.; G. J. Hinde, Esq., Ph.D.; W. H. Hudleston, Esq., M.A., F.R.S.; Prof. T. McKenny Hughes, M.A., F.R.S.; J. W. Hulke, Esq., F.R.S.; Prof. J. W. Judd, F.R.S.; J. E. Marr, Esq., M.A., F.R.S.; H. W. Monckton, Esq.; Clement Reid, Esq., F.L.S.; J. J. H. Teall, Esq., M.A., F.R.S.; W. Topley, Esq., F.R.S.; Prof. T. Wiltshire, M.A., F.L.S.; Rev. H. H. Winwood, M.A.; H. Woodward, Esq., LL.D., F.R.S.; H. B. Woodward, Esq.

Officers.—*President*: W. H. Hudleston, Esq., M.A., F.R.S. *Vice-Presidents*; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; L. Fletcher, Esq., M.A., F.R.S.; G. J. Hinde, Esq., Ph.D.; Prof. J. W. Judd, F.R.S. *Secretaries*: H. Hicks, Esq., M.D., F.R.S.; J. E. Marr, Esq., M.A., F.R.S. *Foreign Secretary*: J. W. Hulke, Esq., F.R.S. *Treasurer*: Prof. T. Wiltshire, M.A., F.L.S.

The thanks of the Fellows were unanimously voted to the retiring Members of Council: Dr. W. T. Blanford, Dr. J. Evans, James Carter, Esq., J. C. Hawkshaw, Esq., and F. W. Rudler, Esq.

II.—February 24, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "The Raised Beaches, and 'Head,' or Rubble-Drift, of the South of England; their Relation to the Valley-Drifts and to the Glacial Period; and on a late Post-Glacial Submergence.—Part II." By Joseph Prestwich, D.C.L., F.R.S., F.G.S. (For Part I. see p. 136.)

The ossiferous deposits of the Caves of Gower are shown to be contemporaneous with the raised sand-dunes between the beaches and the 'head,' and reasons are given for supposing that the elevation of land which preceded their formation need not necessarily have been greater than 120 feet. The mammalian fauna of these

caves is the last fauna of the Glacial or post-Glacial period, and the 'head' or Rubble-drift marks the closing chapter of Glacial times.

Evidence is given for considering that the 'Rubble-drift' has a wide inland range, and that to it are to be referred the 'Head' of De la Beche, the Subaerial Détritus of Godwin-Austen, the Angular flint drift of Murchison, and in part the 'trail' of Fisher and the 'warp' of Trimmer, as well as other deposits described by the author. The accumulation is widespread over the South of England, and occurs in the Thames Valley, on the Cotteswold Hills, and on the flanks of the Malverns. The stream-tin détritus of Cornwall and the ossiferous breccia filling fissures (which must be distinguished from the ossiferous deposits of the true caves) are held to be representatives of the 'Rubble-drift,' which is of a variable character.

The author discusses the views of previous writers on the origin of the accumulations which he classes together as 'Rubble-drift,' and points out objections to the various views. He considers that they were formed on upheaval after a period of submergence which took place slowly and tolerably uniformly: and that the absence of marine remains and sedimentation shows the submergence to have been short. This submergence cannot have been less than 1000 feet below present sea-level, and was shortly brought to a termination by a series of intermittent uplifts, of which the 'head' affords a measure, sufficiently rapid to produce currents radiating from the higher parts of the country, causing the spread of the surface-détritus from various local centres of higher ground. The remains of the land animals killed during the submergence were swept with this débris into the hollows and fissures on the surface, and finally over the old cliffs to the sea- and valley-levels. Simultaneously with this elevation occurred a marked change of climate, and the temperature approached that of the present day. The formation of the 'head' was followed in immediate succession by the accumulation of recent alluvial deposits; so that the Glacial times came, geologically speaking, to within a measurable distance of our own times, the transition being short and almost abrupt.

In this paper only the area in which the evidence is most complete is described. The author has, however, corroborative evidence of submergence on the other side of the Channel.

2. "The Pleistocene Deposits of the Sussex Coast, and their Equivalents in other Districts." By Clement Reid, Esq., F.L.S., F.G.S. (Communicated by permission of the Director-General of the Geological Survey.)

The gales of last autumn and early winter exposed sections such as had not before been visible in the Selsey Peninsula. Numerous large erratic blocks were discovered, sunk in pits in the Bracklesham Beds. These erratics included characteristic rocks from the Isle of Wight. The gravel with erratics is older, not newer as is commonly stated, than the Selsey 'mud-deposit' with southern mollusca. Numerous re-deposited erratics are found in the mud-deposit, which is divisible into two stages, a lower, purely marine, and an upper, or *Scrobicularia*-mud, with acorns and estuarine shells.

At West Wittering a fluviatile deposit, with erratics at its base and stony loam above, is apparently closely allied to the mud-deposit of Selsey; it yields numerous plants, land and freshwater mollusca, and mammalian bones, of which lists are given.

The strata between the brickearth (= Coombe Rock) and the gravel with large erratics yield southern plants and animals, and seem to have been laid down during a mild or interglacial episode. A similar succession is found in the Thames Valley and in various parts of our eastern counties.

III.—March 9, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "The New Railway from Grays Thurrock to Romford: Sections between Upminster and Romford." By T. V. Holmes, Esq., F.G.S.

In the Hornchurch cutting of the new railway, Boulder-clay, of which about 15 feet is seen, rests upon the London-clay near the 100-feet contour-line, and is overlain by 10 to 12 feet of sand and gravel. The author gives reasons for inferring that this sand and gravel belong to the oldest terraces of the Thames Valley gravel occurring in this district, and states that it demonstrates the truth of Mr. Whitaker's conclusion that the Thames Valley deposits are (locally) post-Glacial, or newer than the local Boulder-clay.

2. "The Drift Beds of the North Wales and Mid-Wales Coast." By T. Mellard Reade, Esq., C.E., F.G.S.

This paper is a continuation of papers by the author on the Drift Beds of the N.W. of England and North Wales. The author first treats of the Moel Tryfaen and other Caernarvonshire drifts; he describes the drifts of the coast and coastal plain, connecting his observations with those of the Moel Tryfaen drifts. An important feature of the investigation is the numerous mechanical analyses of the various clays, sands, and gravels. In all the samples but one, a large proportion of extremely rounded and polished quartz-grains have been found, which the author maintains to be true erratics, and a certain sign of marine action. He shows that the Moel Tryfaen marine sands are in part overlain by typical Till, composed almost wholly of local rocks with a small percentage of clay, whereas the sands and gravels are full of erratics including rocks from Scotland and the Lake District, numerous flints, Carboniferous Limestone, and crystalline schists. Throughout the drifts of the coastal plain he has found a greater or less proportion of granite erratics, as well as, in many cases, minute rolled shell-fragments. He maintains that these drifts are the result of two opposing forces, one radiating from Snowdonia, and the other acting from the sea to the southwards, and their characteristics change as the one or the other force preponderated.

The other divisions of the paper are taken up with a description of the Merionethshire drift and that of Mid-Wales, numerous sections being given. Attention is called to a remarkable glaciation of the rocks at Barmouth.

In a concluding part, giving inferences and suggestions, the author

discusses the land-ice and submergence hypotheses, and concludes that his observations distinctly strengthen the grounds for believing in a submergence of the land to an extent of not less than 1400 feet.

An Appendix contains details of nineteen mechanical analyses of tills, sands, and gravels, and a bibliography of papers, observations, and theories of the high-level drifts of Moel Tryfaen.

CORRESPONDENCE.

READE'S THEORY OF MOUNTAIN BUILDING.

Sir,—Mr. Jukes-Browne seems to holds peculiar, not to say exacting, views of the way scientific controversy should be conducted. Having replied to Mr. Davison's criticisms on a fundamental principle, without a rejoinder from him, though nearly a year has since elapsed, I am now invited to go on answering him until some unnamed but "good physicists" are satisfied. I need hardly say that this is a labour I must decline. At the same time, I am ready to meet fairly any good physicists who are prepared to speak in their own names.

T. Mellard Reade.

March 9th, 1892.

ON A FAULT WITHOUT A THROW.

Sir,—The north-western part of the Wirral—the district forming the western horn of Cheshire—is very extensively faulted. The prevailing direction of the faults is north and south, but at places east and west faults are met with. These abut against the north and south faults and are generally terminated by them.

A remarkable characteristic of many of these east and west faults is that although they possess slickensided faces and there is evidence of great movements, there is little or no throw.

A very good example is ~~now~~ exposed near Caldy Grange Grammar School, West Kirby. There is a fine flank exposure of a north and south fault just behind the school. It was described by Mr. O. W. Jeffs in 1887 (Proc. Liverpool Geol. Soc. vol. v. p. 247). He mentioned three east and west faults which terminated against the main fault. Since that time another east and west fault has been exposed and was described by Messrs. Beasley and Lomas before the Liverpool Geological Society in February, 1892. This fault has been traced westwards from the main fault for about a third of a mile, and in one part forms a ridge of fault-rock beautifully slickensided about 6 feet wide and rising like a wall above the surrounding Upper Bunter to a height of 6 to 8 feet.

A transverse section is seen in a little cutting west of the Waterworks, and the beds are continued across the fault without the slightest displacement.

Similar east and west faults have been noticed at Storeton and other places, but, so far as I can ascertain, no satisfactory theory has been advanced to explain their peculiarities.

In the Caldy Grange fault the Keuper has been faulted down against the Bunter. It does not follow that the Keuper would move

at the same rate or at the same time along the whole distance of the north and south fault. If we grant differential motion, the matter is explained. The Keuper might slip to a certain point and fracture there, then the other portion falling would slickenside the face, and a throw equal to that of the main fault might leave no residual throw.

J. Lomas, Assoc. N.SS.

OBITUARY.

HENRY NORTON, F.G.S.

By the death of Henry Norton, of Norwich, we have to record the loss of an enthusiastic student of Norfolk geology, and one of the most learned men of the present century. He was the son of William Norton, Esq., of Old Buckenham, and in his youth was articled to Messrs. Mitchell & Clarke of Wymondham, and afterwards set up practice as a solicitor in Surrey Street, Norwich. Possessed of ample means, he relinquished his profession to devote himself to travelling in the East and throughout Europe. Once, no doubt because of the eccentricity of his conduct, he was apprehended in Vienna as a spy. For many years Mr. Norton devoted himself to the study of Sanskrit, Syriac, Chinese, and other Eastern languages, in which he became so proficient that he was able to read the works of Eastern philosophers and savants in their own tongue. He was also a good Scandinavian and German scholar. Of late years he applied himself a great deal to the study of modern science and philosophy, and more especially to the geology of Norfolk.

He joined the Norwich Geological Society when it was first established in 1864, and became a Fellow of the Geological Society of London in 1875.

He examined in great detail the sections at Pakefield and Kessingland, and read before the Norwich Society a paper in 1876 (published in the 'Norfolk Chronicle' for May 6). A subsequent communication on the 'Forest Bed of East Norfolk' was issued separately (reprinted from the 'Norwich Mercury' of May 5, 1877); and in this paper he boldly and acutely discussed the evidence that had been published on the subject of stumps of trees being rooted *in situ* in the Cromer Forest Bed. He showed that the published evidence was inconclusive. In 1877 Mr. Norton contributed some notes on species of *Hydrobia* from the Freshwater Beds of Runton and Mundesley (Proc. Norwich Geol. Soc. vol. i. p. 16). In 1879 he read a paper embodying great research on the Atlantis Island, coming to the conclusion that it was in reality the continent of Africa (Proc. N.G.S. vol. i. pp. 75, 80). In 1880 he communicated to the same society (*Ibid.* p. 110) notes on the Palæontology of the Ancients (Greeks and Romans); and also an explanation of the word "Paramoudra" (*Ibid*, p. 132).

He died in February last, in his 80th year. [Some further particulars of his life were given in the "Eastern Daily Press" of February 24.]